Elettra Sincrotrone Trieste

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Electra 2.0
Technical Specification Document: Controls

Motion Control - Plant Hardware	
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4	03/09/2025	all	Update and new translation from official italian "Controllo del Moto - Componenti di Impianto." rev. 7
3	22/05/2023	5.3.3	EN60204-1 reference added.
2	19/10/2022	2.2 + 2.3	Working on limit switch prohibited; Home switch added; SSI number of bit specified
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Index

1 INTRODUCTION

This document sets out the guidelines and technical characteristics of the motion system used in Elettra-Sincrotrone Trieste (Elettra-ST).

1.1 Purpose of the document

This document contains the specifications of motors, encoders, limit switches and their wire grouping in junction boxes (JB).

1.1.1 Movement control

”Motion Control” refers to hardware and software components that allow the movement of physical objects (mirrors, gratings, vacuum chambers, etc ...) through the use of motors, encoders and related electronics.

We report here only the most important components:

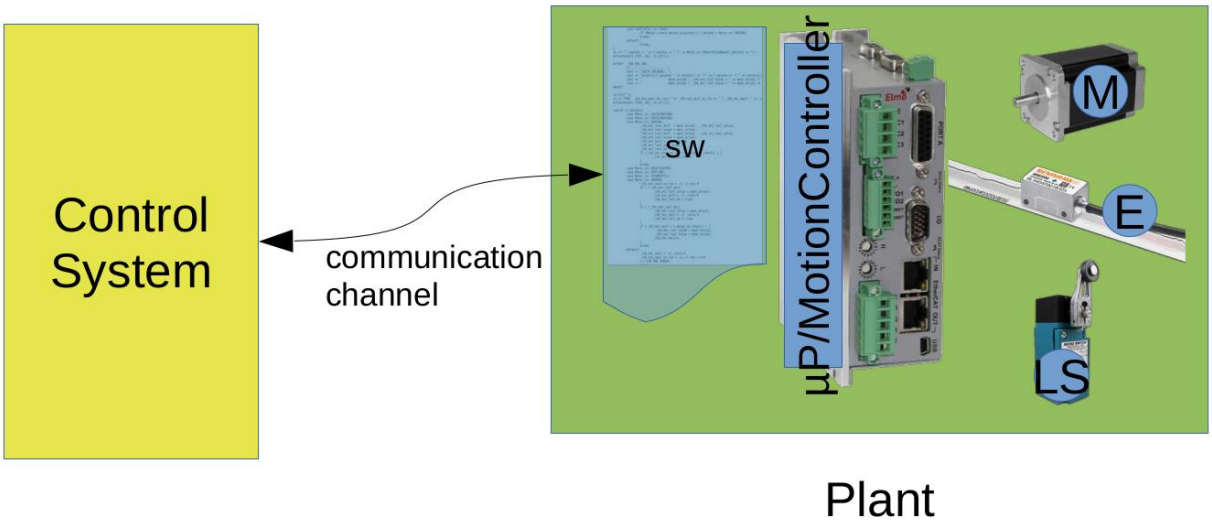


Figure 1 -- Sistema di movimentazione

- M, motor
- LS, end of stroke “limit switch”/sensors
- E, position encoder
- µP/MotionController + sw (*software*), power electronics, motion controller and software
- *Control System*, Control and supervision system

Motors (M) and limit switches (LS) are the basic elements of a motorized axis and therefore **MUST** always be present.

1.1.2 Basic recommendation

All components used must be previously agreed upon with the Executive Director of the Contract (DEC) indicated by Elettra-Sincrotrone Trieste (Elettra-ST).

2 COMPONENTS: MOTORS, LIMIT SWITCHES/SENSORS AND POSITION ENCODERS

2.1 Motors (M)

Various types of “motor” can be used in electromechanical drives:

- 2-phase stepper
- 3-phase stepper
- 5-phase stepper
- direct current
- brushless
- piezoelectric
- pneumatic drive
- etc...

The reference motors at Elettra-ST are:

- **2-phase stepper**
- **5-phase stepper**

In relation to proven performance requirements, the following engine types can also be considered:

- Brushless
- Piezoelectrics

The above mentioned motors can be installed both in atmospheric environments and inside vacuum chambers.

2.1.1 2-phase stepper motors

The 2-phase stepper motor can have 200 or 400 steps/revolution; the current must not exceed 5 A per phase.

Normally the drive is powered at 24V with current control suitable for the chosen motor.

2.1.1.1 Microsteps (*microstepping*)

The 2-phase stepper motor can be operated using the electrical subdivision technique of the mechanical step, microstepping.

The reference controller used at Elettra-ST can reach 256 microsteps for a single mechanical *step*.

2.1.1.2 Wiring

2-phase motors are normally supplied with:

- 4 cables
- 6 cables
- 8 cables

the grouping of the motor wires in the 4-wire terminals must preferably be done in the junction box (JB).

2.1.2 5-phase stepper motor

The 5-phase stepper motor must not exceed 4.5A per phase.

Normally the drive is powered at 24V with current control suitable for the chosen motor.

2.1.2.1 Microsteps (*microstepping*)

The 5-phase stepper motor can be operated using the electrical subdivision technique of the mechanical step, microstepping.

The microstep in the Elettra-ST reference controller can be either 1 or 2 microsteps/step.

2.1.2.2 Wiring

5 phase stepper motors are normally sold with:

- 5-wire (pentagon connection already inside the motor)
- 10-wire

the grouping of the motor wires in the final 5 wires is carried out inside the drive (after the JB and the extension cable), therefore it is not done inside the junction box (JB).

In the case of a pentagonal connection already made at motor level, it will be necessary to check full compatibility with the Elettra-ST reference controller.

2.1.3 Holding current at standstill / brake

There may be the following cases in which the kinematics remains stationary in equilibrium:

1. the kinematic mechanism remains stationary even without torque generated by the motor
2. it is necessary that the motor generates torque, but lower than that necessary to make the kinematics move
3. the presence of a brake is necessary, otherwise the torque required from the motor would produce unnecessary overheating

In the three cases mentioned above, it will be necessary to indicate:

- the actual possibility of powering off the motor
- the current required to keep the kinematics in position
- the presence, type and characteristics of the brake

If an electromechanical brake is to be used, it must be one of the following:

- braking action with brake powered off
- no braking action with brake powered at 24V and max 1A.
- it is necessary to indicate any overheating situations of the powered brake.

2.1.4 In-vacuum motors

In the case of in-vacuum motors, these must be equipped with a temperature sensor to monitor any overheating.

2.1.4.1 Connections through vacuum feedthroughs

If the motor operates in vacuum, the motor phases, brake cables, and limit switches must be connected to a specific set of connectors, while the encoder cables must be connected to a different connector. They must be appropriate vacuum feedthrough connectors. The choice of connectors and their pinout is up to the Designer/Maker of the vacuum chamber and its motors. It is mandatory to deliver detailed documentation in this regard.

The connectors must be inserted into dedicated flanges, the signals will then be collected in the usual junction box, JB.

2.2 Limit Switches/Sensors (LS)

Limit switches/sensors delimit the useful stroke of the motorized axis, they can be:

- Mechanical switch
- Electronic switch/sensor (opto-switches, magnetic sensors, etc.)

Both types of switches/sensors MUST be of the "NORMALLY CLOSED" type, i.e. if NOT activated/engaged they must present a CLOSED electrical circuit.

If mechanical switches are used, their electrical terminals must be voltage-free.

If electronic switches are used, they will be powered by the control electronics. For this purpose, the reference control electronics used at Elettra-ST provides a voltage of 5V (the possibility of having 24V must be discussed in advance with the DEC at Elettra-ST).

Electronic switches must be open-collector (emitter grounded), NPN. The collector circuit closes on the pull-up resistor and the photoemitter in the control electronics.

2.2.1 Positioning of limit switches

It is preferable **not to use stop limit switches in mechanical collision.** In any case, their design must allow the axis to decelerate after the activation of the limit switch in question. If it is not possible to avoid the use of limit switches in mechanical collision, the maximum operating speeds and minimum decelerations must be indicated.

In any case the position where the limit switch is activated must not be used as an allowed working position.

A good rule (even if not obligatory) is to place the limit switch called RLS (Reverse Limit Switch) "close" to the motor, while the one called FLS (Forward Limit Switch) "far" from the motor: in this way, decreasing the position (steps) of the motor you get closer to it and to RLS, while increasing the position (steps) of the motor you move away from it and get closer to FLS.

2.2.2 Wiring

It is good practice and it is recommended to carry all the limit switch signals individually in the JB, and only inside group homologous signals (e.g. the "earth / ground / negative polarity /gnd" returns).

It is good practice and recommended: NOT to use the metal structure of the system as a return "cable" (earth/ground) for the signals.

2.2.3 Variants

Any other type of limit switch must be previously agreed with the DEC indicated by Elettra-ST .

There can also be an additional sensor/switch/"limit switch" (not at the mechanical stop collision) placed along the useful stroke; it is usually indicated with "HOME" and its activation indicates the achievement of a particular position. This can be activated or disactivated while the system is passing over it, and its position is an allowed working position.

2.3 Position encoder (E)

The purpose of the encoder is to provide a measurement, as exact as possible, of the real position reached by the kinematics, therefore, if the use of encoders is indicated in the specification, they must be placed as close as possible to the end of the kinematic chain.

2.3.1 General information and interfaces

Encoders can be:

- digital

- analog

The former are more precise but more sensitive to ionizing radiation, the latter are simpler but more subject to electromagnetic interference and errors; the choice is made based on the operating conditions and the desired precision.

As well, they may be:

- incremental
- absolutes
- semi-absolutes

The first ones require an "initialization" phase to decide the reference point and value, the second ones, already upon power-up, provide a measurement of the current position, the third ones also require an initialization phase albeit on a minor run.

In general cases we have:

- incremental, absolute or semi-absolute digital
- absolute analog

The interfaces for the encoders are:

- incremental and semi-absolute digital encoders (note 1):
  - A/A, B/B and I/I signals (also called Z/Z, i.e. digital sine/cosine)
  - electrical levels according to the RS 422 standard
  - 5V power supply

- analog encoders:
  - pure potentiometer

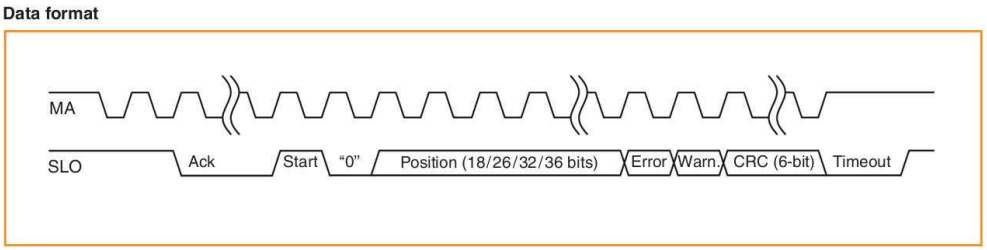
  or
  - 4-20 mA with 5/12 V power supply (/ 24 V, to be agreed)

Note 1:

Semi-absolute optical encoders must be compatible with ACU-RITE© Position-Trac ™ technology.

The following interfaces may be used only after reaching a specific agreement with the Controls Group of Elettra-ST

- absolute digital encoders:
  - SSI interface (Synchronous Serial Interface)
    - 5V power supply
    - maximum of 31 bits for data, with or without Status/Error bit (LSB) (32-bit data with or without Status/Error bit is treated as 31-bit data, justified to the most significant bit, MSB, and therefore without the least significant bit, LSB)
    - Clock frequency: 500 – 2000 kHz
  - BiSS-C Interface:
  - The structure of the BiSS-C protocol is as follows:



The master-slave signal communication format is RS485/RS422 differential line-driven.

Where MA is the clock generated by the master and sent to the encoder, and SLO is the data sent from the encoder to the master. Both conform the electrical specification RS485/RS422.

BiSS-C-N1 Note: In case of encoder error, the ENTIRE system (Yams+encoder) MUST be switched off and switched on again.

Therefore the following specifications must be adhered to:

- 5V power supply
- Ack: maximum time: 20 µs

- Clock frequency, MA, 370kHz to 1.6MHz
- Bits of the “Position” field: from 12 to 31 (including the “0” bit at the beginning of the same field, thus reducing the maximum number of useful position bits to 30), binary coding
- “SINGLE TURN” type encoder
- The Yams system does not include a mechanism for compensation for the length of the cables, so that their maximum length is limited by the clock frequency used:

MA clock	Maximum cable length
250kHz	**95m**
1MHz	**20m**
2MHz	**8m**

BiSS-C-N2 Note: as the number of BiSS-C encoders connected to the Yams increases (from 0 to 8), the refresh and execution time of each motorized axis also increases, an increase even more significant if the controller is required to process the encoder values in a particular way: therefore, it is again noted that the use of this type of encoder must be carefully analysed and discussed with the personnel of Elettra-ST.

2.3.2 Recommendations

In the case of the use of relative digital encoders, a version with a marker signal or reference index (I/I or Z/Z) is strongly recommended.

The use of encoders with a "marker"/reference index is strongly recommended; in this case, the "marker" must be within the useful travel that the motorized axis will travel and therefore within the space delimited by the two limit switches (see relevant paragraphs). A too close proximity to one of the two limit switches can cause a lack of detection of the marker itself.

Some encoders have diagnostic LEDs on the measuring heads. If these are mounted inside the vacuum chambers and/or in situations where even the faint light of the LEDs

can be collected by the measurement instrumentation of the experimental chamber, this must be highlighted, evaluated and communicated to the DEC designated by Elettra-ST. In some cases, a situation like the one described in this paragraph may affect the proper collection and analysis of scientific data.

If analog encoders with 4-20mA current interface are used, the resolution necessary to compare it with the consequent digitization process present in the Elettra-ST reference controller must be agreed in advance. Keep in mind that analog signals can suffer from inaccuracy due to analog noises.

3 OTHER MOTORS, LIMIT SWITCHES AND ENCODERS

When the project and/or the required performance specifications lead to the adoption of motors of a different type than those indicated in the previous paragraphs (i.e. 2 or 5 phase stepper), prior approval by the contract DEC indicated by Elettra-ST is required, both for as regards motors, encoders, limit switches but also for the controller chosen for non "standard" elements.

Any controllers for such items (like piezoelectric motor) must be provided by the Contractor/Builder/Designer with the prior approval of the DEC indicated by Elettra-ST.

4 PLANT

4.1 Useful stroke, over stroke

The movement stroke must be limited by limit switches in both directions, with a repeatability of 0.1 mm. The extra travel with respect to the useful section can be established by the Contractor/Maker/Designer, but it cannot be less than 3% of the useful section in both directions. Further movements must be precluded by mechanical stops.

The entire useful stroke (including the extra stroke) must be reachable without causing damage and/or malfunctions to any part of the system.

Hence, the recommendation to avoid the use of collision stop limits is included.

4.2 Initialization, safety and possible collisions

A movement system is defined as intrinsically safe when all the axes can be moved independently of each other and in any position without causing damage to any part

of the system. If the system is not, the Contractor/Maker/Designer must provide suitable means and/or constructions (electrical, electronic, etc.) designed to prevent collision between parts of the system. The particular technical solutions must be previously discussed and approved by Elettra-ST.

Remember that each axis must be "initialized". During the initialization phase, the coordinates of the origin of the axis are found and set. In this phase the motor must move along the entire useful stroke, and therefore any "anti-collision" solutions must NOT preclude the correct execution of the axis initialization phase.

4.3 Junction Box (JB)

The wiring of the motors, of the relevant limit switches and of the encoders must be collected in one or more boxes (called junction box, JB), supplied by the Contractor/Maker/Designer and suitably fixed to the supports of the mechanical system. These have the purpose of collecting the various signals (and/or power inputs) in connectors which, by type and pinout, must be fully compatible with the specifications adopted by Elettra-ST, see the relevant chapter. In any case, the JB will have:

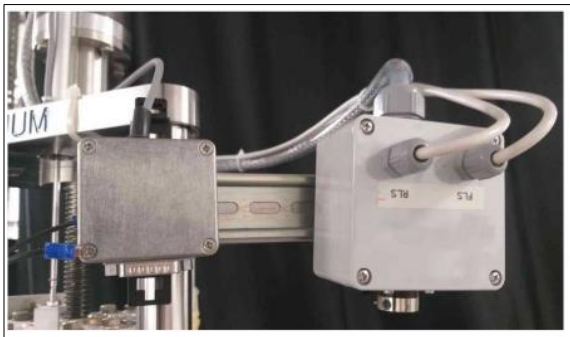
- for 2-phase stepper motors and related limit switches:
  - 12-pin male Trident type circular panel connectors
- for 5-phase stepper motors and related limit switches:
  - 19-pin male Trident type panel circular connectors
- for encoders:
  - 15-pin male sub-D type panel connectors
- for any other element:
  - type and pinout to be agreed with DEC indicated by Elettra-ST

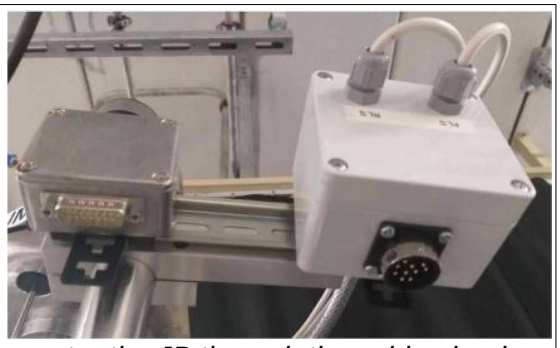
If the plant includes or foresees inclusion of a future update that consists in adding motors/limit switches/encoders, this must already be considered by making the appropriate holes in the JB, so that the future connectors can be easily added.

4.3.1 Recommendation

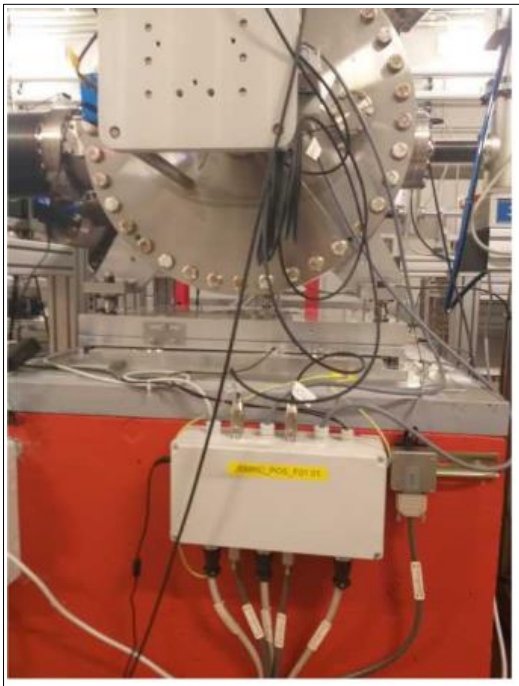
The positions, dimensions and accessibility of the junction boxes must be evaluated and agreed with Elettra-ST, in order to allow easy maintenance of the system.

4.3.2 *Examples of implementation*





The motor and limit switch cables of the system enter the JB through the cable glands, which have the standard connector used at Elettra-ST



In this JB the front drilling allows you to add pre-assembled connectors.

4.4 Wiring

4.4.1 Good practice

It is good practice and it is recommended to carry all the signals (cables) individually to the JB, and only inside make any grouping of similar signals (e.g. the "earth/ground/negative polarity/gnd" returns): this facilitates any possible post-installation troubleshooting.

It is good practice and it is recommended NOT to use the metal structure of the system as a return "cable" (ground/earth) for signals. The connection between the metallic structure of the plant and the ground point of the controllers must be made in the JB, and must be able to be sectioned (even simply through the presence of screw terminal blocks).

4.3.1 Variants

The Contractor/Manufacturer/Designer is entitled to propose alternative solutions for the connections between motors, position encoders, etc. and the controllers. These solutions will be evaluated in advance with the DEC indicated by Elettra-ST in relation to Elettra-ST standards and the location of the equipment at Elettra-ST.

5 STANDARD FOR CONNECTORS AND CONNECTIONS OF MOTORS, LIMIT SWITCHES AND ENCODERS AT ELETTRA-ST

5.1 Connector and connections for motor and limit switches

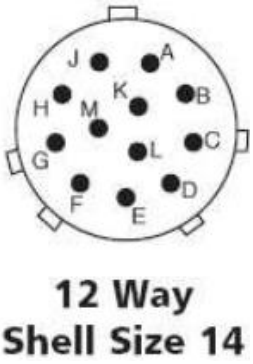
5.1.1 2-phase stepper motor

Motor reference connector for JB:

Cannon Trident Connector System – Ringlock Circular Connector

12 Reversed Receptacle — Pin Contacts

Type ITT-CANNON 192926-0460



Pin	Function	Pin	Function
A	Motor phase A+	G	RLS
B	Motor phase A-	H	HOME
C	Motor phase B+	J	Brake+
D	Motor phase B-	K	Estop in
E	Opto+	L	GND
F	FLS	M	PE

Motor phases A+, A-, B+, B-

These are the phases for the 2 phase stepper motor power.

Opto+

Positive supply voltage for any electronic limit switches (FLS / RLS / HOME).

FLS

"Positive" (forward) limit switch: If shorted to GND, the motor is NOT on this limit switch.

RLS

"Negative" (reverse) limit switch: If shorted to GND, the motor is NOT on this limit switch.

HOME

Reference switch (home).

Brake+

Brake supply/deactivation voltage (max 1Amp @ 24Vdc, return to GND): “no current”/0V = brake active, “current present”/24V = brake deactivated.

Stop in

Motion lock input, active with +24V or disconnected (motion is enabled if this input is short-circuited to GND)

GND

Ground return.

PE

Protective earth.

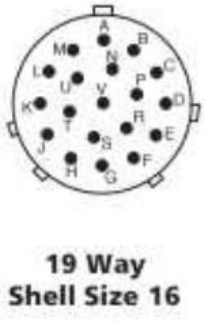
5.1.2 5-phase stepper motor

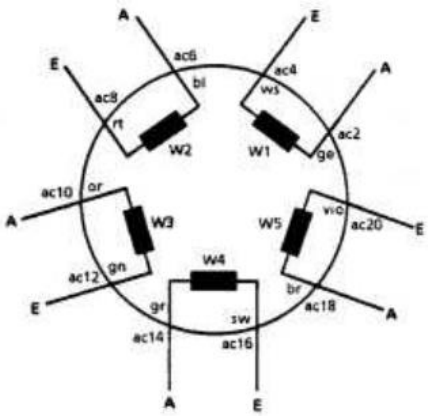
Motor reference connector for JB:

Cannon Trident Connector System – Ringlock Circular Connector

19 Reversed Receptacle — Pin Contacts

Type ITT-CANNON 192926-0470





Pin	Function	Pin	Function
A	Motor phase W1E	K	Estop in
B	Motor phase W1A	L	GND
C	Motor phase W2E	M	PE
D	Motor phase W2A	N	Motor phase W3E
E	Opto+	P	Motor phase W3A
F	FLS	R	Motor phase W4E
G	RLS	S	Motor phase W4A
H	HOME	T	Motor phase W5E
J	Brake+	U	Motor phase W5A

The naming is similar to that used in the two-phase motor, except the motor phases are named W1A/W1E to W5A/W5E.

5.2 Connector and connections for encoders

Encoder reference connector for the JB:

15 - pin male panel connector,
sub-D type

Pin	Function	Pin	Function
1	RS422 Encoder A+	9	RS422 Encoder A-
2	GND	10	Reserved
3	RS422 Encoder B+	11	RS422 Encoder B-
4	+5V	12	Reserved / DATA+
5	AIN_Power+	13	Fault / DATA-
6	AIN_Power-	14	RS422 Encoder I+ / CLK+
7	RS422 Encoder I- / CLK-	15	AIN_Power_GND
8	AIN		

RS422 – digital encoder signals: A+/A-, B+/B-, I+/I-

These are the quadrature signals and the encoder index.

Fault

Error signaling signal (currently not implemented).

+5V / GND

+5V power supply and return (GND) for encoder power supply.

Digital encoders with SSI/BiSS-C interface: DATA+/DATA-, CLK+/CLK-

These are the balanced data and clock signals of the SSI/BiSS-C interface.

AIN_Power+ / AIN_Power- / AIN_Power_GND

Positive (+), negative (-) and ground power supply for analog encoders.

AIN

Analog encoder signal.

5.2.1 Note

Only one type of encoder can be connected to the same connector at a time.

5.3 Extension cables

5.3.1 Motor cables

The extension cables for motors are always made with male-female connectors and with "pin to pin" connections (pin 1 male to pin 1 female, etc ...).

The cable shield must be provided via a cable lug on both sides of the extension cable.

5.3.2 Encoder cables

The extension cables for encoders are always made with male-female connectors and with "pin to pin" connections (pin 1 male to pin 1 female, etc ...). Some signal encoders or of the balanced type, so that twisted pairs of wires are necessary. The following signals are associated with the various pairs:

Pin	Function	twisted pair wires
1 - 9	RS422 encoder: A+/A-	Pair 1
2 - 4	GND / +5V	Pair 2
3 - 11	RS422 encoder: B+/B-	Pair 3
5 – 6	AIN_Power+ /AIN_Power-	Pair 4
7 – 14	RS422 encoder: I- / I+ or SSI/BISS-C: CLK- / CLK+	Pair 5
8 – 15	AIN / AIN_Power_GND	Pair 6
12 – 13	Reserve / Fault or SSI/BISS-C: DATA+/DATA-	Pair 7
10	reserve	Pair 8 (single wire of the pair)

The shielding of the twisted pair must be connected to the metal part of the connector at both ends.

5.3.3 Recommendation

The extension cables should be connected pin to pin, so that they are neutral and interchangeable with any motor of the system

5.3.4 Maximum length

The extension cables may not be longer than 30 m.

5.3.5 Motors and limit switches

The following cable sections are recommended:

- for 2-phase stepper motors:
    - for motors up to 2 A / phase: 12 x 0.5mmq (0.75mmq, Note 1) cable + shield

- for motors from 2 to 5 A / phase: cable 12 x 1mmq + shield

- for 5-phase stepper motors:
  - cable 19 x 0.82mmq + (possibly) shield

Note 1:

A motor with its extension cable is an “electrical device of the system”, and so it must conform to the requirements of the European Standard EN 60204-1, and all relevant documents.

See clause about “wiring outside/inside enclosures”, “power circuits” and multicore cables.

5.3.6 Encoder

The use of a shielded, twisted-pair cable is required.

The following cable is recommended:

- 8-pair braided cable with 24AWG section + shield

The use of the following color code is recommended (DIN47100 table 9):

Twisted pair cable	Colors
pair 1	white - brown
pair 2	yellow - green
pair 3	gray - pink
pair 4	red - blue
pair 5	black - purple
pair 6	gray/pink – red/blue
pair 7	white/yellow – brown/yellow
pair 8	white/green

6 DOCUMENTATION

At the same time as presenting all the electrical drawings necessary for the construction and assembly of the system (including JB), the Contractor/Maker/Designer must also communicate the technical specifications of the motors and encoders that will be used and must provide the complete list of materials.

The real connection conditions must be faithfully, clearly and exhaustively reported in the wiring diagrams.

The Contractor/Maker/Designer must also deliver the wiring diagrams in Altium Design format or in AutoCad format (dwg or dxf extensions).

7 TESTS AND VERIFICATIONS

If the supply of motor controllers is not required as the controllers supplied by Elettra-ST will be used and if the Contractor/Builder/Designer needs a stepper motor controller for the test phases during the development and assembly of the system, Elettra-ST undertakes to supply one (1) unit (maximum number of controllable axes: 8) with control computer, appropriate software (which only allows simple actions with motors and encoders) and the training necessary for its use. The relative request (including the list of motors, limit switches, encoders and their combinations) must reach Elettra-ST sufficiently in advance (not less than two months) with respect to requirements. Any training will be carried out at the headquarters by Elettra-ST.

Elettra Sincrotrone Trieste

Elettra 2.0
Technical Specification Document: Controls

Fast interface for monochromators and undulators motion control

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PLEASE NOTE: This is an English courtesy translation of the original documentation prepared in Italian language. Only the original version in Italian language has legal value.

Elettra Sincrotrone Trieste

Table of Contents

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1. INTRODUCTION

With technological progress in the IT field and with the contextual increase of calculation speed, generically, of electronic computers, interfaces and protocols already consolidated communication tools become interesting and usable even in soft-realtime systems or even realtime systems.
In this context, this document specifies interfaces and protocols communication to be used within the so-called "fast interface" for the motion control of monochromators and undulators.

2 INTERFACE

In reference to the OSI model (acronym for Open Systems Interconnection, also known improperly as the "ISO/OSI model"), the levels of are adopted described below.

2.1 Physical level

The physical layer adopted complies with the IEEE 802.3 standard, which provides baseband cable transmissions only, at speeds of 10, 100 and 1000 Mbit/s, on twisted pairs (shielded and unshielded) and optical fibres, among the acronyms of reference: 10BASE-T, 100BASE-T, etc...
In order to reduce traffic on the physical layer, only point-to-point connections are considered point between the two communicating entities (client and server).

2.2 Network and transport layers

The UDP/IP protocol is adopted for these two levels. The size of the UDP datagram (or packet) is equal to the MTU (Maximum Transmission Unit) standard (1500 bytes).
Particular needs could lead to considering the use of so-called "jumbo packets", but this will have to be assessed on a case-by-case basis.

2.3 Application level

2.3.1 Server-software (Srv), client-software (Clt)

The role of server-software (Srv, server) is assumed by the entity that remains waiting of information and/or requests for actions sent by the client-software (Clt, client).

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The server (Srv) in addition to waiting for requests sent by the client, is responsible to send, publish, on a cyclical basis, the significant data (defined by the particular application). The client receives the published data from the server and sends its requests to the server. The architecture can be exemplified by identifying the server as a whole hardware/software (programmable controller, "motion" system) that it implements the operation of a motorized system that accepts positioning commands. While identifying the client with the hardware/software set (PC or similar) that calculates and requests the tracking of a particular sequence/trajectory of positions.

2.3.2 Fast interface life time

Both can be established between client and server, in a mutually exclusive manner the fast interface described by this document is a different interface "traditional", for example based on TCP/IP. The two interfaces, mutually exclusive, must provide mechanisms for switch between using one and then the other interface. If the two interfaces exist on two distinct physical levels (i.e. network cards), they can coexist, as long as the processing unit to which they are connected does not induces a reciprocal decrease in computing speed.

2.4 Data publication

2.4.1 Establishment of the publication channel

In the case of a single transmission channel, the client, through the "traditional" interface, asks the server to open a UDP communication channel with it. For this purpose the server must receive the IP address and UDP port number data to use. Once communication has been established, the server will begin to publish its data and remain online waiting for any requests sent by the client.

2.4.2 Data publication frequency

The server publishes data on the fast interface (i.e. transmits) at a fixed frequency significant. The fixed cadence value must be able to be set (via the interface "traditional"), with values between 2 ms and 100ms with 1ms step. The value of default should be 10 ms.

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2.4.3 Data in the publication

The published data may be "raw" with a fixed structure (for example as a copy of memory area) or structured (json format or others), however they must be contained in a single UDP packet within a single frame Standard MTU (1500 bytes).

2.5 Sending requests/commands

2.5.1 Establishment of the publication channel

The client opens a UDP communication channel to the server. To communication Once established, the client will be able to send commands to the server.

2.5.2 Cadence of sending commands

The client will be able to send commands to the server with an arbitrary frequency; it, however, it may be even shorter than 10 ms.

2.5.3 Command processing time

Let Tc be the cycle time of the motion system's position control loop, then the commands received from the server must be accepted and executed within Tc (typically 1 or 2 ms).

2.5.4 Data in the command

The data in the command may be "raw" with a fixed structure (for example as a copy of memory area) or structured (json format or others), however they must be contained in a single UDP packet within a single frame Standard MTU (1500 bytes).

3 FUNCTIONS REQUIRED FROM "MOTION" SYSTEMS

As mentioned, the server can be identified in the hardware/software package (controller programmable, "motion" system) that implements the operation of a system motorized and accepts positioning commands. The "motion" system, therefore, must present particular functionalities additional (compared to the basic ones necessary for traditional positioning).

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They can be summarized with the "Tracking" functionality position" (Positiong Tracking, PT) or "Cyclic [synchronous] positioning" (Cyclic Synchronous Positioning, CSP).

3.1 "Traditional" operation

In this operating mode the motion systems have their own system designed to operate the positionings. Interfaces, communication protocols and the functionalities themselves are those required by the usual specifications.

3.2 Position tracking (PT)

The controller/system in PT mode allows you to change the absolute position when receiving the relevant command. New positions can be given in the same direction or in the opposite direction to the position current. The controller will then calculate a new trajectory based on the new one position using the acceleration, deceleration and speed parameters that are currently set. There is no pre-established limit to the frequency with which you can change the final position, however the controller updates the information on the position at its cycle frequency, indicative no worse than 1 msec. The controller generates a "straight" trajectory between two successive requested positions. The motion profile in this mode is trapezoidal, with an initial speed ramp dictated by the set acceleration and final speed ramp dictated by the set deceleration. By setting appropriate (high) acceleration values e deceleration, the profile may approach the rectangular.
Even if the mechanics of the plant impose speed limits (V plant_max), acceleration (A implant_max) and deceleration (D implant_max), within the scope of this functionality the aforementioned values must not be limits even for the setting of related parameters: the trajectory generator (client) will be responsible for sending the correct one temporal sequence of new positions and new speeds so that the speeds,accelerations and decelerations consequently achieved are within limits "mechanics".

3.3 Cyclic Synchronous Positioning (CSP)

Synchronous cyclic positioning is a standardized operating mode of the drives, defined in the profile specification CiA 402, CANopen for drives and motion control and included in the IEC 61800-7 standard: "Systems of Variable speed electric drives — Part 7: Generic interface and use of profiles for drive systems".
This control mode is often used with multi-axis systems that require coordinated movement and can be used on various Ethernet networks, including EtherCAT, CANopen over Ethernet (CoE) and Ethernet POWERLINK. As part of the fast interface presented in the previous paragraphs, the synchronicity is no longer guaranteed but it comes close considering the connection point-to-point between client and server, that the data packet is

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unique (UDP) and that the packet transfer speed on networks 100Mb/s, 1Gb/s or others is minimal, as much as the jitter present on the network can be minimal.
We cannot, therefore, strictly speaking, talk about CSP, but we are very close, therefore In this context we will continue to talk about CSP. The various implementations of CSP on drivers/controllers involve configuring the cycle time (not expected in the context of the fast interface), but they can plans to modify, in addition to the position, also the speed. Therefore in the latter case and in the present context, PT and CSP can be considered equivalent.

4 EXAMPLES

Let's consider the example in which we want to make the gap execute a particular trajectory
of an undulator so that the resulting velocity in energy is constant.

4.1 "Fast" operation (PT/CSP)

In this mode the client has the task of calculating, from the desired energy values and from their cadence, the position and speed values to be sent to the server (system motion).
v... = speed
p... = positions
T0: clt->srv msg_udp(“Gap”: {“Velocity”: <#v0>, “Gap”: <#g0>})
|
|
T1=T0+Tk: clt->srv msg_udp(“Gap”: {“Velocity”: <#v1>, “Gap”: <#g1>})
|
|
.....

4.1.1 Published data

The server publishes its data cyclically; if the structured form is contained in the Standard MTU then can be as below:

“Gap”: {“Velocity”: <number>, “Gap”: <number>, “Offset”: <number>, “Taper”: <number>}
“Phase”: {“Velocity”: <number>, “Phase”: <number>, “Mode”: <integer>}
for i = 1 to N:

"axisN": {“Velocity”: <number>, “Position”: <number>, “Encoder”: <integer>, "Status":<integer>}

or, if the data in the structured form exceeds UDP MTU, it can be adopted for i data

gap-velocity [float]
gap-value [float]
offset-value [float]
taper-value [float]
phase-velocity [float]
phase-value [float]
mode-value [integer 32]
N times:

speed [float]
position-value [float]
encoder-value [integer 64]
status [integer 32]

the following encoding:

<number> ANSI/IEEE Std 754-1985 - IEC 60559:1989, Binary floating-point: "Bit Number"
<number> ANSI/IEEE Std 754-1985 - IEC 60559:1989, Binary floating-point: "Bit Number"
<number> ANSI/IEEE Std 754-1985 - IEC 60559:1989, Binary floating-point: "Bit Number"
<number> ANSI/IEEE Std 754-1985 - IEC 60559:1989, Binary floating-point: "Bit Number"
<number> ANSI/IEEE Std 754-1985 - IEC 60559:1989, Binary floating-point: "Bit Number"
<number> ANSI/IEEE Std 754-1985 - IEC 60559:1989, Binary floating-point: "Bit Number"
<number> uint32_t
N times:
<number> ANSI/IEEE Std 754-1985 - IEC 60559:1989, Binary floating-point: "Bit Number"
<number> ANSI/IEEE Std 754-1985 - IEC 60559:1989, Binary floating-point: "Bit Number"
<number> uint64_t
<number> uint32_t

with "Bit Number": {32 bit / 4 byte} or {64 bit / 8 byte}

In these examples, in the unstructured form there are: 6 x (4 or 8) bytes + 4 bytes + N x {2 x (4 or 8) +12 } bytes
so 28 + N x 20 bytes

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or 52 + N x 28 bytes
with N= 6: 148 bytes in the first case and 142 in the second.

4.1.2 Commands

In the context of the example the commands can be:

“Gap”: {“Velocity”: <number>, “Gap”: <number>}
As well as':
“Gap”: {“Acceleration”: <number>, “Deceleration”: <number>}

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