User Manual

E727T0012, valid for E-727.AS

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E-727.AS Digital Multi-Channel Piezo Controller

With Area Scan Routines for Fast Optical Alignment in Silicon Photonics Production

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Contents

Other Applicable Documents

This document describes the area scan routines provided by the E-727.AS for fast optical alignment. See the documents listed below for all other functionality of the E-727.AS. Refer to the E-727.3SDA model regarding hardware descriptions in the E727T0005 user manual.

Description	Document
E-727 Digital Multi-Channel Piezo Controller	E727T0005 User Manual
PI General Command Set (GCS)	PZ281E GCS Commands Manual for E-727
F-131.3SD1 fiber alignment system	F131T0001 Technical Note
PIMikroMove	SM148E Software Manual

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INFORMATION

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➢ Contact our customer service department (p. 27).

INFORMATION

For products that are supplied with software (CD in the scope of delivery), access to the manuals is protected by a password. Protected content is only displayed on the website after entering the access data.

You need the product CD to get the access data.

For products with CD: Get access data

1. Insert the product CD into the PC drive.
2. Switch to the Manuals directory on the CD.
3. In the Manuals directory, open the Release News (file including ***releasenews*** in the file name).
4. Get the access data for downloading protected content in the "User login for software download" section of the Release News. Possible methods for getting:
   - Link to a page for registering and requesting the access data
   - Direct input of user name and password

5. If the access data needs to be requested via a registration page:
   a) Follow the link in the Release News.
   b) Enter the required information in the browser window.
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General procedure:

1. Open the website **www.pi.ws**.
2. If access to the manuals is protected by a password:
   a) Click ***Login***.
   b) Log in with the user name and password.
3. Click ***Search***.
4. Enter the product number up to the period (e.g., P-882) or the product family (e.g., PICMA® Bender) into the search field.
5. Click ***Start search*** or press the Enter key.
6. Open the corresponding product detail page in the list of search results:
   a) If necessary: Scroll down the list.
   b) If necessary: Click ***Load more results*** at the bottom of the list.
   c) Click the corresponding product in the list.
7. Click the ***Downloads*** tab.

   The manuals are shown under ***Documentation***.
8. Click the desired manual and save it to the hard disk of your PC or to a data storage medium.

Product Description

Fast Optical Alignment with E-727.AS

E-727.AS Fast Alignment Routines and Parameters

E-727.AS is based on the E-727.3SDA standard controller. Both models share the same hardware, but differ in their firmware: Instead of the DDL function provided by E-727.3SDA, the E-727.AS offers area scan routines for fast optical alignment in silicon photonics production.

The settings for configuration of the fast alignment routines can be made or queried via the fast alignment commands (p. 12), but also via the parameters of the “fast alignment” parameter group (p. 27).

If you do not want to deal with commands and parameters, you should consider using the C-990.FA1 Software for Automatic Photonics Alignment (p. 6) which allows the user to configure and execute the routines easily.

INFORMATION

The commands and parameters for the DDL function do appear in the response to HLP? and HPA? commands, however, they have no effect.

F-131.3SD1 Photonics Alignment System

The E-727.AS controller is part of the F-131.3SD1 photonics alignment system available from PI. Further system components are three stacked M-111 linear stages, a three-axis P-611 NanoCube® nanopositioner, and a C-884.4DC controller for DC motors.

E-727.AS controls the axes of the P-611 NanoCube® nanopositioner, and C-884.4DC controls the stacked M-111 linear stages.

For more information on the F-131.3SD1 system hardware, see the F131T0001 Technical Note.

Figure 1: F-131.3SD1 photonics alignment system: M-111 linear stages and P-611 NanoCube® nanopositioner

The F-131.3SD1 system is designed to align optical components—transmitter or receiver— so that the maximum optical power is measured on the receiver side.

Transmitter and receiver of the alignment system are optical fibers. During the alignment of transmitter or receiver in axes x, y and z, the power of the optical signal (light) is measured on the receiver side with a power meter (F-712.PM1 available as optional accessory, p. 11). The power meter converts the optical power into an analog signal that is fed into the controllers.

C-990.FA1 Software for Automatic Photonics Alignment

The C-990.FA1 software, which is available as an optional accessory (p. 11), allows the user to operate the F-131.3SD1 system and similar PI systems in scanning applications easily. The program makes it possible to configure and execute spiraled area scans (for the E-727.AS: spiral scan with constant frequency; for details, see the description of the FDR command, p. 13). The user can choose to go to the maximum intensity that was found or go back to the start position.

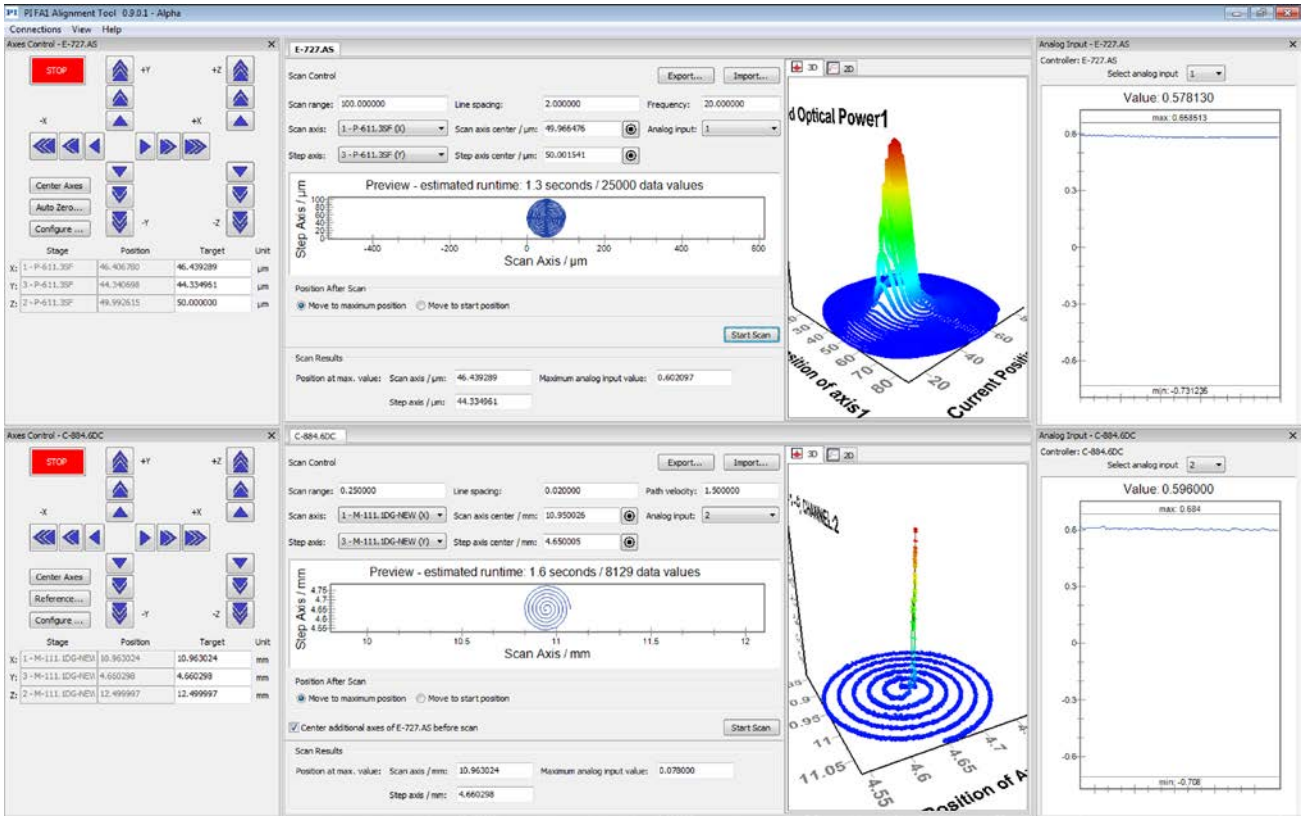
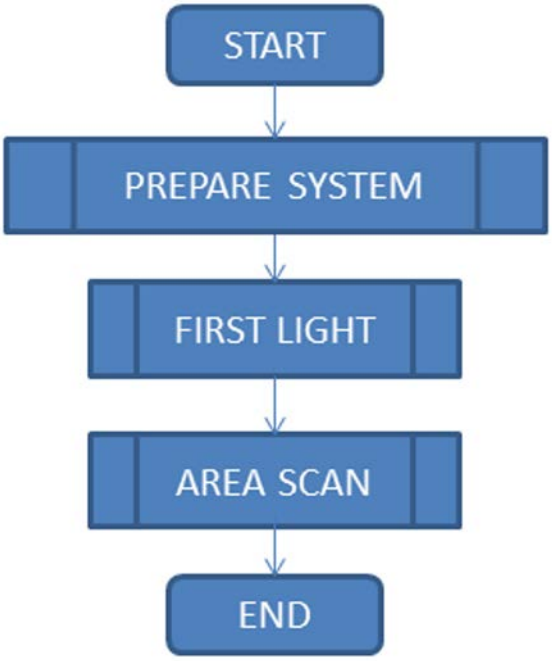


Figure 2: C-990.FA1 PI FA1 alignment tool

Fast Optical Alignment—Procedure

"System" in the descriptions below means the F-131.3SD1 photonics alignment system (p. 5).



Prepare system:

Make sure that the system functions properly. To ensure this, start a few motion tests of the axes in PIMikroMove. A new adjustment of the closed-loop performance is absolutely necessary whenever you change the load on the P-611 NanoCube® nanopositioner, e.g., by attaching, removing or replacing a fiber holder.

See the E727T0005 user manual and the user manual of the C-884 controller for instructions.

The PIMikroMove software and the user manuals are provided on the E-727 and C-884 product CDs which are in the scope of delivery of the F-131.3SD1 system.

First light:

First-light search can be done using the ***Axes Control*** panels of theC-990.FA1 software (p. 6). Use the stacked M-111 linear stages for rough positioning (C-884), and the P-611 axes for fine positioning (E-727).

Area scan:

Use the C-990.FA1 software to configure and execute spiraled area scans to find the position of the maximum intensity of the optical signal.

Product View

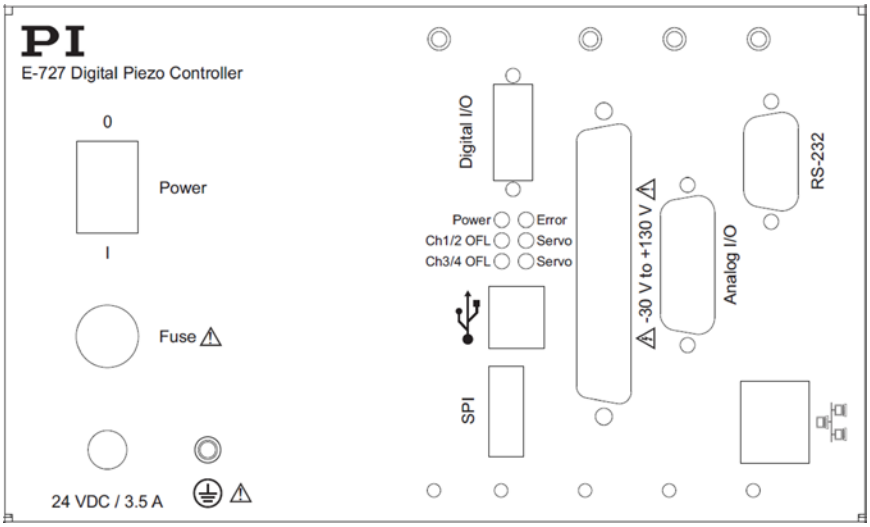


Figure 3: Front panel of E-727.AS digital piezo controller

Labeling	Type	Function
Power	Toggle switch 	Power on/off switch: ▪ O position: E-727 is switched off ▪ | position: E-727 is switched on
Fuse ⚠	Slotted fuse holder 	For cartridge fuse 5 x 20 mm, changing the fuse see E727T0005 user manual
24 VDC	M8 panel plug, 4-pin	Connection for the supply voltage. To be used with the K050B0003 adapter (included in the scope of delivery)
⏚ ⚠	M4 hole with fastening material for protective earth conductor	Protective earth connection A protective earth conductor must be connected to the E-727 via the M4 hole and the fastening material, since the E-727 is not grounded via the power supply connector.
Digital I/O	MDR14 (f)	Digital lines: ▪ Outputs: Triggering of external devices, output of the servo cycles ▪ Inputs: Triggering of data recorder or wave generator, use in macros, reboot of E-727

Labeling	Type	Function
Power	LED green	Power-on and ready indicator: ▪ Continuously lit: E-727 is ready for normal operation ▪ Continuously off: E-727 is not connected to the supply voltage ▪ Alternately lit/off/lit: E-727 performs power-on or reboot sequence
Error	LED red	Error indicator: ▪ Continuously lit: Error (error code ≠ 0) ▪ Continuously off: No error (error code = 0) ▪ Alternately lit/off: E-727 performs power-on or reboot sequence The error code can be queried with the ERR? command. The query resets the error code to zero and the LED is switched off.
Ch1/2 OFL **Ch3/4 OFL**	LED yellow	Overflow indicator for the axes: ▪ Continuously lit: At least one of the axes is in overflow state ▪ Continuously off: No axis is in overflow state ▪ Both **OFL** LEDs are flashing together with the **Servo** LEDs: E-727 searches for a DHCP server during power-on or reboot sequence ▪ At least one **OFL** LED is permanently flashing while all other LEDs are off: Firmware update failed (details see “Updating Firmware” in the E727T0005 user manual) The overflow state of the individual axes can be queried with the OVF? command. The overflow state can only occur in closed-loop operation. In the overflow state, the axis does not reach the target position because the amplifier(s) has/have reached the range limit. In this case, readjustment of the sensor zero-point is necessary, using the AutoZero functionality provided by the E-727 firmware (details see E727T0005 user manual). For an axis in overflow state, the corresponding bit in the response to the #5 command (Request Motion Status) is **not** set (motion state = “not moving”).

Labeling	Type	Function
Ch1/2 Servo **Ch3/4 Servo**	LED green	Servo mode indicator for the axes: ▪ Continuously lit: Servo mode is on (closed-loop operation) for at least one of the axes ▪ Continuously off: Servo mode is off (open-loop operation) for the axes ▪ Flashing: E-727 initializes parameters and – if the OFL LEDs are flashing in addition - searches for a DHCP server during power-on or reboot sequence The servo mode of the individual axes can be queried with the SVO? command.
	USB-B socket	Universal serial bus for connection to the PC
SPI	Display port	Connection to SPI (serial peripheral interface) master. Can be used for transferring position data from and to the E-727 with minimum latency and update rates as high as the servo update rate of the E-727. It is also possible to send and receive ASCII data so that the connected master has full access to the PI General Command Set (GCS). See “SPI-Interface” in the E727T0005 user manual for details.
-30 V to +130 V	D-Sub 37 (f) 	Socket for piezo stages; carries the voltage for the piezo actuators (-30 to 130 V) and the signals of the sensors in the mechanics.
Analog I/O	D-Sub 15 (f), pinout on p. 33 	Analog lines: ▪ Inputs: Used for area scan routines for fast optical alignment. Can also be used as external sensors or as analog control inputs ▪ Outputs: Three sensor monitor lines, and one line that can be used to monitor the position of an axis or for controlling an external amplifier
RS-232	D-Sub 9 (m)	Serial connection to PC via UART, voltage level RS-232
	RJ45 socket	Ethernet interface for communication via TCP/IP, see E727T0005 user manual for details

Scope of Delivery

The following table lists the scope of delivery related to E-727.AS. For the complete scope of delivery of the F-131.3SD1 system, see the documentation for F-131.3SD1.

Item number	Description
E-727.AS	Digital piezo controller
000023194	Separate 24 V wide-range-input power supply (120 W/5 A) for use with line voltages from 100 to 240 VAC and voltage frequencies of 50 or 60 Hz, with barrel connector
3763	Power cord
K050B0003	Adapter for the power supply connection; barrel connector to M8 4-pin connector
C-815.34	RS-232 null-modem cable, 3 m, 9/9-pin Not for E-727.xxxF and .xxxAF models.
C-815.563	Cross-over network cable for direct connection with the PC via TCP/IP
000011448	USB cable (type A to type B) for connection to the PC
E-727.CD	Product CD with software and user manuals for the E-727
E727T0012	User Manual for the E-727.AS, this document
E-727.IO3x	Analog input cable, D-Sub 15 (m) to open end, 1 m. For further details, see p. 34.

Accessories

Order number	Description
C-990.FA1	PI FA1 alignment tool, software for automatic fiber alignment, for use with C-884 controller for motorized axes and E-727.AS controller with fast alignment routines (spiraled area scan) for piezo axes with strain gauge sensors.
F-712.PM1	Optical Power Meter for 400-1550 nm Wavelength Range, to 1 mA Input Current, 20 kHz Signal Bandwidth, Logarithmic Output ±5 V, Benchtop Device, including Power Adapter
F-603.BNC	Adapter set for the connection of the analog input signal to the controllers (e.g., E-727.AS and C-884.4DC): ▪ Box with four BNC inputs and a D-Sub 25 (m) output ▪ Y cable D-Sub 25 (f) to HD D-Sub 26 (m) and D-Sub 15 (m)

Fast Alignment Commands

Command Overview

Command	Syntax	Description
FDR (p. 13)	FDR <routine name> <scan axis> <scan axis range> <step axis> <step axis range> [L <threshold level>] [A <alignment signal input channel>] [F <frequency>] [V <velocity>] [MP1 <scan axis middle position>] [MP2 <step axis middle position>] [TT <target type>] [CM <estimation method>] [ST <stop position option>]	Defines a fast alignment area scan routine. The current valid definition can be queried with FRR?
FRC (p. 20)	FRC <routine name> {<routine name coupled>}	Couples fast alignment routines to each other.
FRC? (p. 20)	FRC? [{<routine name>}]	Gets coupled fast alignment routines.
FRS (p. 21)	FRS {<routine name>}	Starts a fast alignment routine.
FRP (p. 21)	FRP {<routine name> <routine action>}	Stops, pauses or resumes a fast alignment routine.
FRP? (p. 22)	FRP? [{<routine name>}]	Gets the current state of a fast alignment routine.
FRR? (p. 23)	FRR? [<routine name> [<result ID>]]	Gets the results of a fast alignment routine.
FRH? (p. 25)	FRH?	Lists descriptions and physical units for the routine results that can be queried with the FRR? command.
SIC (p. 25)	SIC <FA input channel ID> <calculation type> [{<calculation parameter>}]	Defines calculation settings for an analog input channel.
SIC? (p. 26)	SIC? [{<FA input channel ID>}]	Gets the calculation settings for an analog input channel.
TAV? (p. 26)	TAV? [{<FA input channel ID>}]	Gets voltage value of an analog input channel.
TCI? (p. 27)	TCI? [{<FA input channel ID>}]	Gets calculated value of an analog input channel.

Command Descriptions

FDR (Set FA Area Scan Definition)

Description: Defines a fast alignment area scan routine.

Area scan routine details:

An area scan is performed to find the position of the global intensity maximum of the measured signal in a given area.

The following types of area scans are supported:

- Spiral scan with constant frequency (default)
- Spiral scan with constant path velocity
- Sinusoidal scan: The scan axis follows a sine curve while the step axis follows a ramp. The motion results in a raster that covers the scan area. The start position is at one edge of the scan area.

With a spiral scan, the motion of scan axis and step axis results in a spiral that covers the scan area. The start position is the center of the (square) scan area. A spiral scan is useful when the point of interest is in the center of the scan area. Furthermore, a spiral scan is faster than a sinusoidal scan.

An area scan routine has been successfully completed when the following condition has been met:

- The analog input signal has reached a given minimum intensity threshold in the scanned area at least once.

An area scan has been unsuccessfully completed in the following cases:

- The given minimum intensity threshold has not been reached in the scanned area.
- FRP with stop action, #24, STP or HLT has been sent: Scan and step axis remain in the current position.

Arguments in square brackets are optional.

The maximum number of routines that can be defined is 3.

Use FRS to start the routine. With FRR?, you can read out the definition and the results of the routine.

The settings defined with FDR can also be made by changing parameters with SPA (for the corresponding parameters see the argument descriptions below; note that changing a parameter value with SPA requires switching to command level 1 with CCL). If the settings made with FDR are to be preserved when the E-727.AS is switched off or rebooted, they have to be saved to nonvolatile memory with WPA; see the E-727 commands manual (PZ281E).

Format: FDR <routine name> <scan axis> <scan axis range> <step axis> <step axis range> [L <threshold level>] [A <alignment signal input channel>] [F <frequency>] [V <velocity>] [MP1 <scan axis middle position>] [MP2 <step axis middle position>] [TT <target type>] [CM <estimation method>] [ST <stop position option>]

Arguments: <routine name>

The identifier of the routine. Can be 1, 2, or 3.
Note that the <routine name> value is to be used as item identifier when changing parameters of the Fast Alignment parameter group with SPA or SEP commands.

<scan axis>

Identifier of the axis that is to be the master axis of the scan routine.

<scan axis> must be > 0.

With a sinusoidal scan, the scan axis follows a sine curve.

<scan axis> sets the value of the ***FA Axis*** parameter for the scan axis (ID 0x20000000) in the volatile memory.

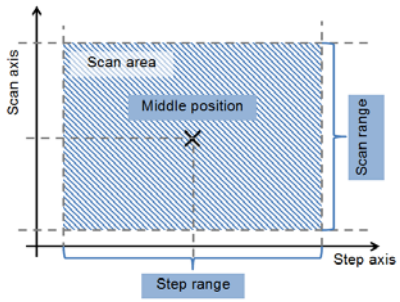
<scan axis range>

Scan range for the scan axis.

Spiral scan with constant frequency: The scan axis range value gives the side length of the square covered by the spiral.

Spiral scan with constant path velocity: The scan axis range value gives the final radius of the spiral.

Sinusoidal scan: The range value is used to calculate the start and end position for the scan axis as follows (middle position is given by MP1, see below):
Start position = scan_axis_middle_position – scan_axis_range/2)
End position = scan_axis_middle_position + scan_axis_range/2



<scan axis range> sets the value of the ***FA Area Scan Range*** parameter for the scan axis (ID 0x20000200) in the volatile memory.

<step axis>

Identifier of the step axis.

To define a single-axis routine, <step axis> must be 0 or identical to <scan axis>.

With a sinusoidal scan, the step axis follows a ramp.

<step axis> sets the value of the ***FA Axis*** parameter for the step axis (ID 0x20000001) in the volatile memory.

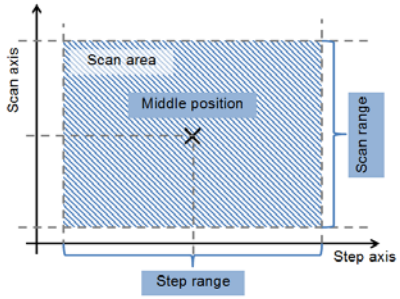
<step axis range>

Scan range for the step axis.

Spiral scan with constant frequency: The step axis range value is not used. The side length of the square covered by the spiral results from the scan axis range value, see above.

Spiral scan with constant path velocity: The step axis range value gives the distance between successive turns of the spiral.

Sinusoidal scan: The range value is used to calculate the start and end position for the step axis as follows (middle position is given by MP2, see below):
Start position = step_axis_middle_position – step_axis_range/2
End position = step_axis_middle_position + step_axis_range/2.



<step axis range> sets the value of the ***FA Area Scan Range*** parameter for the step axis (ID 0x20000201) in the volatile memory.

[L <threshold level>]

L: Required keyword

<threshold level>: Minimum intensity threshold of the analog input signal. If during an area scan routine no value of the analog input signal is equal to or greater than the given minimum threshold level, FRR? will report “not successful” for the routine. The unit of <threshold level> is V.

<threshold level> sets the value of the ***FA Area Scan Minimum Threshold*** parameter (ID 0x20002900) in the volatile memory. The value of the parameter will remain unchanged in volatile memory if [L <threshold level>] is omitted in the FDR command.

[A <alignment signal input channel>]

A: Required keyword

<alignment signal input channel>: Identifier of the analog input channel whose maximum intensity is sought. Can be 1 to 4, for details, see “Analog I/O” (p. 33).

<alignment signal input channel> sets the value of the ***FA Input Channel*** parameter (ID 0x20000E00) in the volatile memory. The value of the parameter will be set to 1 in volatile memory when both of the following conditions are met:

- [A <alignment signal input channel>] is omitted in the FDR command.
- The current value of the parameter is invalid (e.g. 0).

[F <frequency>]

F: Required keyword

<frequency>: Frequency of the scan axis.

Spiral scan with constant frequency: The frequency value is used to calculate the grid size of the spiral, see TT below.

Spiral scan with constant path velocity: The frequency value is ignored.

Sinusoidal scan: The frequency value gives the frequency of the sine curve for the scan axis.

<frequency> sets the value of the ***FA Area Scan Frequency*** parameter (ID 0x20000D00) in the volatile memory. The value of the parameter will remain unchanged in volatile memory if [F <frequency>] is omitted in the FDR command.

[V <velocity>]

V: Required keyword

<velocity>: Velocity of the step axis.

Spiral scan with constant frequency: The velocity value is used to calculate the grid size of the spiral, see TT below.

Spiral scan with constant path velocity: The velocity value gives the path velocity.

Sinusoidal scan: The velocity value gives the velocity with which the step axis follows a ramp from (step_axis_middle_position – step_axis_range/2) to (step_axis_middle_position + step_axis_range/2)).

If the velocity set with VEL for the step axis is lower than the value given by <velocity>, the velocity is limited to the VEL value.

<velocity> sets the value of the ***FA Area Scan Step Velocity*** parameter (ID 0x20000300) in the volatile memory. The value of the parameter in volatile memory will be set to the current valid velocity of the step axis if [V <velocity>] is omitted in the FDR command.

[MP1 <scan axis middle position>]

MP1: Required keyword

<scan axis middle position>: Middle position of the scan range for the scan axis.

Spiral scans: The value gives the start position for the scan axis.

Sinusoidal scan: The value is used to calculate the start and end position for the scan axis, see description of <scan axis range> above.

<scan axis middle position> sets the value of the ***FA Area Scan Middle Position*** parameter for the scan axis (ID 0x20000100) in the volatile memory. The value of the parameter will remain unchanged in volatile memory if [MP1 <scan axis middle position>] is omitted in the FDR command.

[MP2 <step axis middle position>]

MP2: Required keyword

<step axis middle position>: Middle position of the scan range for the step axis.

Spiral scans: The value gives the start position for the step axis.

Sinusoidal scan: The value is used to calculate the start and end position for the step axis, see description of <step axis range> above.

<step axis middle position> sets the value of the ***FA Area Scan Middle Position*** parameter for the step axis (ID 0x20000101) in the volatile memory. The value of the parameter will remain unchanged in volatile memory if [MP2 <step axis middle position>] is omitted in the FDR command.

[TT <target type>]

TT: Required keyword

<target type>: ID of the area scan type. Possible values:

- 0 = sinusoidal scan (scan axis follows a sine curve, step axis follows a ramp; the motion results in a raster that covers the scan area)
- 1 = spiral scan with constant frequency (the motion of scan axis and step axis results in a spiral that covers the (square) scan area). The spiral expands as follows:
  Grid size = velocity/frequency
  For velocity and frequency, see V and F above.
- 2 = spiral scan with constant path velocity.
  The spiral is defined by:
  <scan axis range> gives the final radius
  <step axis range> gives the distance between successive turns
  <velocity> gives the path velocity
  To keep the path velocity constant, the frequency is constantly changed during the spiral motion, and the frequency given by <frequency> (see F above) is ignored.

<target type> sets the value of the ***FA Area Scan Target Type*** parameter (ID 0x20002B00) in the volatile memory. The value of the parameter will remain unchanged in volatile memory if [TT <target type>] is omitted in the FDR command.

[CM <estimation method>]

CM: Required keyword

<estimation method>: ID of the estimation method for the position of the global intensity maximum:

- 0 = no estimation. Global maximum is at the position where the maximum value was recorded during the scan routine.

<estimation method> corresponds to the value of the ***FA Area Scan Maximum Estimation Method*** parameter (ID 0x20001700) in the volatile memory.

[ST <stop position option>]

ST: Required keyword

<stop position option>: ID of the position to be approached by scan axis and step axis when the area scan routine has been completed:

- 0 = move to scan axis and step axis position with the maximum intensity of the analog input signal
- 1 = stay at the end position of the area scan routine
- 2 = move to the start position of the area scan routine
- 3 = stop at the position where the minimum intensity threshold of the analog input signal is reached (given by <threshold level>). If the area scan has been unsuccessfully completed, scan axis and step axis move back to the start position of the area scan routine.
- 4 = continuously scan the area and stop at the position where the minimum intensity threshold of the analog input signal is reached (given by <threshold level>). The motion continues from start position to end position and back until the threshold is reached or the routine is stopped with FRP, #24, STP or HLT. If a stop command has been sent: Scan and step axis remain in the current position.

<stop position option> sets the value of the ***FA Area Scan Stop Position Option*** parameter (ID 0x20000A00) in the volatile memory. The value of the parameter will remain unchanged in volatile memory if [ST <stop position option>] is omitted in the FDR command.

Additional setting: The routine type is defined via the value of the ***FA Routine Type*** parameter (ID 0x20000F00) as follows:

0 = idle routine (prevents the routine from running when started with FRS)

1 = area scan routine

The parameter value is set to 1 in volatile memory when an FDR command is sent. You can also set the parameter with SPA or SEP commands.

Response:	None
Notes:	The physical unit in which <scan axis range>, <step axis range>, <scan axis middle position> and <step axis middle position> are to be given can be queried with the PUN? command. The routine definition with FDR is only possible when the routine is not running. While a routine is running, the routine definition can be changed via the SPA command and the corresponding parameters of the Fast Alignment group (p. 27).
Example:	FDR 1 1 100 2 100 L -5 A 1 F 20 V 10 MP1 50 MP2 50 TT 0 CM 0 ST 3 Defines an area scan routine with the following settings: ▪ Name of the routine: 1 ▪ Scan axis settings: Axis identifier: 1 Scan range: 100 [axis unit] Middle position of scan range: 50 [axis unit], this results in the start position 50 – 100/2 = -0 Frequency of sine curve: 20 Hz Area scan type: Sinusoidal scan (0) ▪ Step axis settings: Axis identifier: 2 Scan range: 100 [axis unit] Middle position of scan range: 50 [axis unit], this results in the start position 50 – 100/2 = 0 Maximum velocity: 10 [axis unit]/s ▪ Intensity threshold level: -5 V ▪ Identifier of the analog input signal channel whose maximum intensity is sought: 1 ▪ Estimation setting: no estimation. Global maximum is at the position where the maximum value was recorded during the scan routine. ▪ End position of the routine: position where the minimum intensity threshold of the analog input signal is reached

FRC (Set FA Routine Coupling)

Description: Couples fast alignment routines to each other.
Coupled routines are not allowed to stop until all routines coupled to them are finished.

Format: FRC <routine name> {<routine name coupled>}

Arguments: <routine name>
The identifier of a routine. Can be 1, 2, or 3.
<routine name coupled>
The identifier of a routine that is to be coupled to the routine given by <routine name>. Can be 1, 2, or 3. If <routine name coupled> = 0, the routine given by <routine name> is disconnected from any routine.

Response: None

Notes: FRC sets the value of the ***FA Coupled Routines*** parameter (0x20001500) in volatile memory.
If the settings made with FRC are to be preserved when the E-727.AS is switched off or rebooted, they have to be saved to nonvolatile memory with WPA; see the E-727 commands manual (PZ281E).

Example: Couple routine 1 to routine 3:
FRC 1 3
Disconnect routine 1 from any routine:
FRC 1 0

FRC? (Get FA Routine Coupling)

Description: Gets coupled fast alignment routines.

Format: FRC? [{<routine name>}]

Arguments: <routine name>
The identifier of the routine. Can be 1, 2, or 3.

Response: {<routine name>"="<routine name coupled> [{<routine name coupled>}] LF}

where

<routine name coupled> is the identifier of a routine that is coupled to the routine given by <routine name>. Can be 1, 2, or 3. If <routine name coupled> = 0, the routine given by <routine name> is disconnected from any routine.

Notes: FRC? queries the value of the ***FA Coupled Routines*** parameter (0x20001500) in volatile memory.

FRS (Set FA Routine Start)

Description: Starts a fast alignment routine.

The routine must have been defined before with FDR (p. 13) or via the appropriate parameters (p. 27).

With FRP (p. 21), you can stop, pause or resume a routine. Using FRP? (p. 22), you can query the current state of the routine (running or not).

With FRR? (p. 23), you can read out the definition and the results of the routine.

Format: FRS {<routine name>}

Arguments: <routine name>

The identifier of the routine. Can be 1, 2, or 3.

Response: None

Notes: Multiple routines can run synchronously for the axes.

Routines can be coupled to each other with FRC (p. 20).

The type of the routine to be started depends on the value of the ***FA Routine Type*** parameter (ID 0x20000F00). Possible types:

0 = Idle routine (prevents the routine from running when started with FRS)

1 = Area scan routine

FRP (Set FA Routine Stop, Pause or Resume)

Description: Stops, pauses or resumes a fast alignment routine.

A paused routine will be resumed with the routine variable values that were valid at the time of pausing, even if values (e.g. target value) have been changed in the meantime.

A stopped routine will be considered to be unsuccessful.

When a routine is stopped or paused with FRP, the axes will stay at the current target position.

The response to FRP? may show that a routine is still running if the FRP? command has been sent immediately after stopping the routine with FRP. Before proceeding, query FRP? until it returns 0, indicating that the routine has successfully been stopped.

A routine to be stopped or paused must have been started with FRS (p. 21) before.

A routine to be resumed with FRP must have been paused with FRP before.

Format: FRP {<routine name> <routine action>}

Arguments: <routine name>
The identifier of the routine. Can be 1, 2, or 3.
<routine action>
The action to be performed for the routine. Possible actions:
0 = stop the routine
1 = pause the routine
2 = resume the routine

Response: None

Example: Start routines 1 and 2:
FRS 1 2
Pause routine 2:
FRP 2 1
Pause routine 1 and resume routine 2:
FRP 1 1 2 2
Stop routines 1 and 2:
FRP 1 0 2 0
Query the state of routines 1 and 2:
FRP? 1 2
Receive the following response which shows that the routines are still running:
1=2
2=2
Query the routine state again for routines 1 and 2:
FRP? 1 2
Receive the following response which shows that the routines are stopped now:
1=0
2=0

FRP? (Get FA Routine State (Stopped/Paused/Resumed)

Description: Gets the current state of a fast alignment routine.
See FRP for an example.

Format: FRP? [{<routine name>}]

Arguments: <routine name>
The identifier of the routine. Can be 1, 2, or 3.

Response: {<routine name>"="<routine state> LF}

where

<routine state> is the current state of the routine. Possible states:

0 = routine has been stopped / is not running

1 = routine has been paused

2 = routine is running

FRR? (Get FA Routine Results)

Description: Gets the results of a fast alignment routine.

Format: FRR? [{<routine name> <result ID>}]

Arguments: <routine name>

The identifier of the routine. Can be 1, 2, or 3.

If no routine identifier is given, all available results are queried.

<result ID>

The identifier of the result. See below for valid identifiers. Use the response to FRH? (p. 25) to get information on the supported result identifiers.

If no result identifier is given, all available results for the given routine are queried.

Response: {<routine name> <result ID>"="<resulting value> LF}

where

<resulting value> can be as follows for the individual result identifiers:

Result ID	Resulting value
1	Success of the routine: 0 = routine was not successful 1 = routine was successful
2	Intensity maximum of the measured signal The unit of the intensity maximum is V. The result can also be queried via the value of the ***FA Maximum Intensity Value*** parameter (ID 0x20001000).
3	Position of the intensity maximum of the measured signal, in [axis unit] The ID "1" stands for scan axis, ID "2" stands for step axis. The result can also be queried via the value of the ***FA Area Scan Position Of Intensity Maximum*** parameter (ID 0x20000B0n, n = 0 for scan axis, n = 1 for step axis).
4	Routine definition made with FDR (p. 13). The response includes the values of all settings, even if arguments have been omitted in the last sent definition command. The MIIL and MAIL values are not relevant for E-727.AS.
5	Routine time in s The result can also be queried via the value of the ***FA Routine Time*** parameter (ID 0x20002300).
6	Reason for abort of routine: 0 = routine was not aborted. This is the case when the routine is still running or when it has been successfully finished, paused with FRP, or never been running yet. 1 = area scan routine was not successful because the given minimum intensity threshold has not been reached in the scanned area 2 = area scan routine was not successful because the found position of the global maximum results from an estimation method (see FDR for details) and is outside of the scan axis range and/or the step axis range 5 = routine has been stopped
7	Not relevant for E-727.AS
8	Not relevant for E-727.AS

Notes: When evaluating the routine results, first of all check the success of the routine. When the routine was not successful (result ID 1 has the value 0), all other results of the routine are invalid.

Several data recorder options are available for fast alignment routines, see the response to the HDR? command for details.

FRH? (Get Help for Interpretation of FRR? Response)

Description: Lists descriptions and physical units for the routine results that can be queried with the FRR? command (p. 23).

Format: FRH?

Arguments: none

Response: {<result ID>"="<description>TAB<phys unit> LF}

where
<result ID> is the identifier of the result.
<description> is the description of the result.
<phys unit> is the physical unit of the result.

SIC (Set FA Input Calculation)

Description: Defines calculation settings for the given analog input channel.
SIC is only implemented for compatibility reasons.

Format: SIC <FA input channel ID> <calculation type> [{<calculation parameter>}]

Arguments: <FA input channel ID>
The identifier of an analog input channel of the controller. Can be 1 to 4, for details, see “Analog I/O” (p. 33).
<calculation type>
0 = No calculation
<calculation parameter>
The settings for the selected calculation type:
With calculation type 0, no settings are required.

Response: None

SIC? (Get FA Input Calculation)

Description: Gets the calculation settings for the given analog input channel.
SIC? is only implemented for compatibility reasons.

Format: SIC? [{<FA input channel ID>}]

Arguments: <FA input channel ID>
The identifier of an analog input channel of the controller. Can be 1 to 4, for details, see “Analog I/O” (p. 33).

Response: {<FA input channel ID>"="<calculation type> [{<calculation parameter>}] LF}

where

<calculation type> is the calculation type, see SIC for details.

<calculation parameter> gives the settings for the calculation type, see SIC for details.

TAV? (Get Analog Input Voltage)

Description: Gets voltage value of given analog input channel.

Format: TAV? [{<FA input channel ID>}]

Arguments: <FA input channel ID>
The identifier of an analog input channel of the controller. Can be 1 to 4, for details, see “Analog I/O” (p. 33).

Response: {<FA input channel ID>"="<float> LF}
where
<float> is the current voltage at the analog input channel in volts.

Note: TAV? reports the voltage value after the mechanics linearization polynomial (see E727T0005 user manual for linearization details).

TCI? (Get Calculated FA Input)

Description:	Gets calculated value of given analog input channel. TCI? is only implemented for compatibility reasons.
Format:	TCI? [{<FA input channel ID>}]
Arguments:	<FA input channel ID> The identifier of an analog input channel of the controller. Can be 1 to 4, for details, see “Analog I/O” (p. 33).
Response:	{<FA input channel ID>"="<float> LF} where <float> is the current value of the calculated input

Fast Alignment Parameters

Parameter Basics and Handling

Generally, parameters can be changed / queried with SPA / SPA? and SEP /SEP? commands. Note that you have to switch to command level 1 before you can change a parameter value with SPA or SEP (this is not necessary with the fast alignment commands). Parameters which have command level 3 (see table below) are used to display routine results and cannot be changed with commands.

You can query the available parameters and their properties with the HPA? and HPV? commands. For further details regarding parameter handling, see “Parameters” in the E727T0005 user manual.

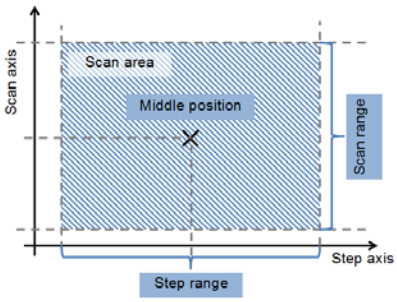
Fast AlignmentParameter Group

The E-727.AS provides the “fast alignment” parameter group for fast alignment routines.

The identifiers of the routines are 1, 2, 3. The routine identifier is to be used in commands as follows:

- Fast alignment commands: <routine name> argument, for examples see the command descriptions in this document
- SPA and SEP commands: <ItemID> argument
  Example: To specify that scan axis and step axis stay at the end position when the area scan routine 3 has been completed, you have to send the following commands:
  CCL 1 advanced
  SPA 3 0x20000A00 1

ID	Description	Corres-ponding Fast Alignment command	Notes	Com-mand level for write access
0x2000000n	FA Axis	FDR (axis argument)	Axis involved in the routine; n = 0 for scan axis, n = 1 for step axis UINT; 1 to 3	1
0x2000010n	FA Area Scan Middle Position	FDR (MP1, MP2 arguments)	n = 0 for scan axis, n = 1 for step axis The use of the parameter depends on the area scan type selected for the routine (parameter 0x20002B00): ▪ Spiral scans: Gives the start position for the axis. ▪ Sinusoidal scan: Used to calculate start position and end position of the routine, see scan range below. FLOAT; min position to max position of axis in [axis unit]	1
0x2000020n	FA Area Scan Range	FDR (axis range arguments)	n = 0 for scan axis, n = 1 for step axis The use of the parameter depends on the area scan type selected for the routine (parameter 0x20002B00): ▪ Spiral scan with constant frequency: The scan axis range value gives the side length of the square covered by the spiral. The step axis range value is not used. ▪ Spiral scan with constant path velocity: The scan axis range value gives the final radius of the spiral. The step axis range value gives the distance between successive turns of the spiral. ▪ Sinusoidal scan: Used to calculate start position and end position of the routine:	1

ID	Description	Corres-ponding Fast Alignment command	Notes	Com-mand level for write access
			Start position = middle position – scan range/2 End position = middle position + scan range/2  FLOAT; range value in [axis unit]	
0x20000300	FA Area Scan Step Velocity	FDR (V argument)	Velocity of step axis The use of the parameter depends on the area scan type selected for the routine (parameter 0x20002B00): ▪ Spiral scan with constant frequency: The velocity value is used to calculate the grid size of the spiral. ▪ Spiral scan with constant path velocity: The velocity value gives the path velocity. ▪ Sinusoidal scan: The velocity value gives the velocity with which the step axis follows the ramp. FLOAT; ≥ 0 [axis unit]/s Note: The parameter value in volatile memory is set to the current velocity of the step axis when an FDR command is sent without the V argument.	1
0x20000A00	FA Area Scan Stop Position Option	FDR (ST argument)	ID of the position to be approached by scan axis and step axis when the area scan routine has been completed: 0 = move to position with the maximum intensity of the analog input signal (default value) 1 = stay at the end position of the area scan routine	1

ID	Description	Corres-ponding Fast Alignment command	Notes	Com-mand level for write access
			2 = move to the start position of the area scan routine 3 = stop at the position where the minimum intensity threshold of the analog input signal is reached (parameter 0x20002900) 4 = continuously scan the area and stop at the position where the minimum intensity threshold of the analog input signal is reached (parameter 0x20002900). The motion continues from start position to end position and back until the threshold is reached or the routine is stopped.	
0x20000B0n	FA Area Scan Position Of Intensity Maximum	FRR? (result ID 3)	Routine result: position of the global intensity maximum of the measured signal, n = 0 for scan axis, n = 1 for step axis Read only FLOAT; min position to max position of axis in [axis unit]	3
0x20000D00	FA Area Scan Frequency	FDR (F argument)	Frequency of the scan axis The use of the parameter depends on the area scan type selected for the routine (parameter 0x20002B00): ▪ Spiral scan with constant frequency: The frequency value is used to calculate the grid size of the spiral. ▪ Spiral scan with constant path velocity: The frequency value is ignored. ▪ Sinusoidal scan: The frequency value gives the frequency of the sine curve for the scan axis. FLOAT; ≥ 0 Hz	1
0x20000E00	FA Input Channel	FDR, FDG (A argument)	ID of the analog input whose maximum intensity is to be found, starts with 1 (for details, see “Analog I/O”, p. 33) INT; 1 to 4	1

ID	Description	Corres-ponding Fast Alignment command	Notes	Com-mand level for write access
			Note: The parameter value in volatile memory is set to 1 when both of the following conditions are met: ▪ An FDR command is sent without the A argument. ▪ The current value of the parameter is invalid (e.g. 0).	
0x20000F00	FA Routine Type		Possible types: 0 = Idle routine (prevents the routine from running when started with FRS) 1 = Area scan routine Note: The parameter value is set to 1 in volatile memory when the FDR commands is sent to configure a routine.	1
0x20001000	FA Area Scan Maximum Intensity Value	FRR? (result ID 2)	Routine result: intensity maximum of the measured signal Read only FLOAT; the unit is V	3
0x20001500	FA Coupled Routines	FRC, FRC?	Bit pattern of the IDs of routines that are coupled to each other. Coupled routines are not allowed to stop until all routines coupled to them are finished. UINT32; 0 to 0xFFFF Bit 0 = routine with ID 1 Bit 1 = routine with ID 2 Bit 2 = routine with ID 3 In the bit pattern of a routine, at least the bit of the routine itself is set.	1
0x20001700	FA Area Scan Maximum Estimation Method	FDR (CM argument)	Estimation method for position of global intensity maximum: 0 = global maximum is at the position where the maximum value was recorded	1
0x20002300	FA Routine Time	FRR? (result ID 5)	Routine result: duration of the routine in s Read only FLOAT32; ≥ 0.0 s	3

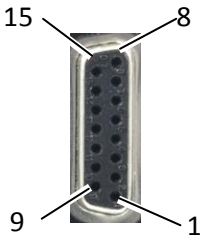
ID	Description	Corres-ponding Fast Alignment command	Notes	Com-mand level for write access
0x20002900	FA Area Scan Minimum Threshold	FDR (L argument)	Minimum intensity threshold of the analog input signal. Criterion for success of the routine. FLOAT; > 0; the unit is V	1
0x20002B00	FA Area Scan Target Type	FDR (TT argument)	Type of area scan: 0 = sinusoidal scan (scan axis follows a sine curve, step axis follows a ramp; the motion results in a raster that covers the scan area) 1 = spiral scan with constant frequency (default value; the motion of scan axis and step axis results in a spiral that covers the (square) scan area). The spiral expands as follows: Grid size = velocity/frequency For velocity and frequency, see parameters 0x20000300 and 0x20000D00. 2 = spiral scan with constant path velocity (the motion of scan axis and step axis results in a spiral that covers the (square) scan area). The spiral is defined by the following parameters: 0x20000200 gives the final radius 0x20000201 gives the distance between successive turns 0x20000300 gives the path velocity To keep the path velocity constant, the frequency is constantly changed during the spiral motion, and the frequency given by 0x20000D00 is ignored.	1

Pin Assignment

Analog I/O

„Analog I/O“ – D-Sub 15 (f)

Pin		Function	Channel ID
1		GND	-
	9	-Analog In 1	1* / 4**
2		+Analog In 1	
	10	-Analog In 2	2* / 5**
3		+Analog In 2	
	11	-Analog In 3	3* / 6**
4		+Analog In 3	
	12	-Analog In 4	4* / 7**
5		+Analog In 4	
	13	GND	-
6		GND	-
	14	Sensor Monitor 1	-
7		Sensor Monitor 2	-
	15	Sensor Monitor 3	-
8		Analog Out 1	Output signal channel 4



The analog inputs are preset for a range of ±10 V.

* ID for use as analog input channel for a fast alignment area scan routine (“fast alignment input channel”)

** ID for use as external sensor or as a control source (“input signal channel”; see “Using the Analog Input” in the E727T0005 user manual)

Important: The identifiers of the fast alignment input channels are **not** used with the data recorder. With the data recorder, the analog inputs are always counted as input signal channels. The means that when you query data with DRR?, the input signal values recorded during a fast alignment routine are available under the input signal channel ID (4 to 7) and **not** under the appropriate fast alignment input channel ID (1 to 4).

For further information on channel identifiers, see „Axes, Channels, Functional Elements” in the E727T0005 user manual.

E-727.IO3x Analog Input Cable

The E-727.IO3x analog input cable splits the input lines of the ***Analog I/O*** socket (p. 27) up into separate wires.

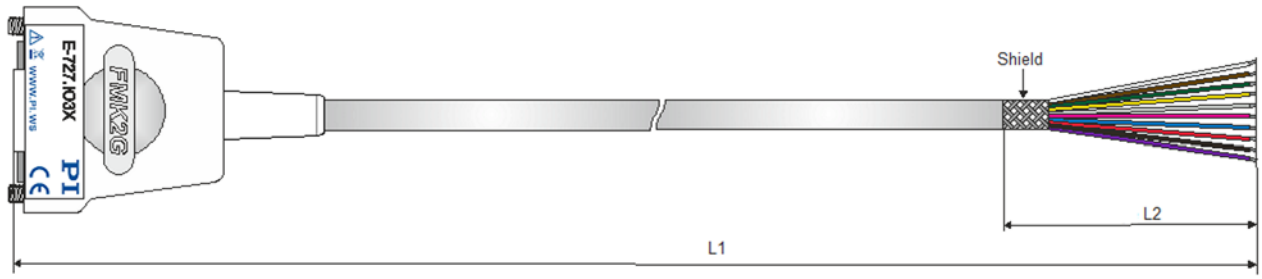


Figure 4: E-727.IO3x cable, D-Sub 15 (m) to open end

L1 = 1 m ±10 cm
L2 = 6 cm ±1 cm

D-Sub 15 (m)	**Signal**	Wire pair	Color
1	GND	Pair 1	brown
9	-Analog In 1	Pair 2	green
2	+Analog In 1	Pair 2	yellow
10	-Analog In 2	Pair 3	grey
3	+Analog In 2	Pair 3	pink
11	-Analog In 3	Pair 4	blue
4	+Analog In 3	Pair 4	red
12	-Analog In 4	Pair 5	black
5	+Analog In 4	Pair 5	purple
13	GND	Pair 1	white
Hood	Shield	Cable shield	---

INFORMATION

When using an analog input of the E-727, both the corresponding +Analog In and –Analog In line must be wired.

Customer Service

For inquiries and orders, contact your PI sales engineer or send us an email (mailto:service@pi.de).

- If you have questions concerning your system, have the following information ready:
  - Product and serial numbers of all products in the system
  - Firmware version of the controller (if available)
  - Version of the driver or the software (if available)
  - Operating system on the PC (if available)
- If possible: Take photographs or make videos of your system that can be sent to our customer service department if requested.

The latest versions of the user manuals are available for download (p. 4) on our website.