Technical Note

JRe, LFa, 2014-06-24
E870T0002, valid for E-870.1G, E-870.2G, E-870.4G

E-870 PIShift Drive Electronics

Models with a Case

Contents

Safety

Intended Use

The E-870 is a laboratory device as defined by DIN EN 61010-1. It is intended to be used in interior spaces and in an environment which is free of dirt, oil, and lubricants.

According to its design, the E-870 is intended for open-loop operation of PIShift piezo inertia drives. The E-870 is a single-channel device. In combination with a demultiplexer (present in the E-870.2G and E-870.4G models), up to 2 and 4 drives respectively can be controlled serially.

The E-870 must not be used for purposes other than those named in the this Technical Note. In particular, the E-870 must not be used to drive ohmic or inductive loads.

General Safety Instructions

The E-870 is built according to state-of-the-art technology and recognized safety standards. Improper use of the E-870 may result in personal injury and/or damage to the E-870.

- Only use the E-870 for its intended purpose, and only use it if it is in good working order.
- Read the Technical Note.
- Immediately eliminate any faults and malfunctions that are likely to affect safety.

The operator is responsible for the correct installation and operation of the E-870.

Organizational Measures

Technical Note

- Always keep this Technical Note available by the E-870.
  If the Technical Note is lost or unusable, contact our customer service department (info@pi.ws).
- Add all information given by the manufacturer, e.g. supplements and other Technical Notes, to the Technical Note.
- If you pass the E-870 on to other users, also turn over this Technical Note as well as all other relevant information provided by the manufacturer.
- Only use the device on the basis of the complete Technical Note. Missing information due to an incomplete Technical Note can result in injuries and property damage.
- Only install and operate the E-870 after having read and understood this Technical Note.

Personnel qualification

The E-870 may only be installed, started up, operated, maintained and cleaned by authorized and appropriately qualified personnel.

Safety Measures during Installation

- Install the E-870 near the power source so that it can be quickly and easily disconnected from the power source.
- Only use cables and connections that meet local safety regulations.

If the protective earth conductor is not or not properly connected, dangerous touch voltages can occur and there is a risk of electric shock in the case of an error. In the case of malfunction or failure of the system, touching the E-870 can result in minor injuries.

- Make sure that the contact resistance is < 0.1 ohm at 25 A at all connection points relevant for the function of the protective earth conductor.
- If the protective earth conductor has to be temporarily removed (e.g. for modifications), reconnect the protective earth conductor before starting the E-870 up again.

Safety Measures during Start-Up and Operation

If the protective earth conductor is not or not properly connected, dangerous touch voltages can occur and there is a risk of electric shock.. In the case of malfunction or failure of the system, touching the E-870 can result in minor injuries from electric shock.

- Only operate the E-870 when a protective earth conductor is connected.

Features and Applications

The E-870 is a power amplifier for open-loop operation of PIShift piezo inertia drives.

The E-870 has a PIShift channel for outputting the piezo voltage. The PIShift channel is optionally controlled via a PC, an SPI interface, a USB joystick, digital or analog control inputs.

If a demultiplexer is used, the PIShift channel can serially operate up to two different piezo inertia drives with the E-870.2G and up four piezo inertia drives with the E-870.4G. The E-870.2G model is equipped with a 1:2 demultiplexer and the E-870.4G model with a 1:4 demultiplexer for this purpose.

The E-870 can be configured for the desired type of controlling and demultiplexing either via the USB interface by PC or via the SPI interface. For connecting the E-870 to an SPI master, see "SPI Interface" (p. 26). For the corresponding configuration without a PC or SPI interface, the E-870 has digital inputs.

Parameter settings for the connected PIShift drive are stored in the E-870's nonvolatile memory. It is necessary to adjust the parameters for initial start-up and subsequently only when there is a change of the connected drive. The parameters are modified by PC via the USB interface or alternatively via the SPI interface.

The commands of the PI General Command Set (GCS) are used for communication between the E-870 and the PC or SPI master. When a PC is used for communication: The E-870 can be put into operation without knowledge of the GCS commands by using the **E-870 Control** PC program, which is included in the scope of delivery. LabVIEW drivers and a program library for programming PC applications are also included in the scope of delivery. For the communication of the E-870 with an SPI master, see "SPI Interface" (p. 26).

Model Overview

E-870.1G PIShift piezomotor / PiezoMike drive electronics, 1 channel, bench-top

E-870.2G PIShift piezomotor / PiezoMike drive electronics, 2 channels, bench-top

E-870.4G PIShift piezomotor / PiezoMike drive electronics, 4 channels, bench-top

Product View

INFORMATION

The E-870.2G and E-870.4G models have an integrated demultiplexer and can therefore serially operate up to 2 (E-870.2G) or 4 (E-870.4G) PIShift drives.

The E-870.1G model does **not** have a demultiplexer, and the sockets **X2**, **X3** and **X4** are **not** populated. All other operating elements are identical to those of the E-870.2G and E-870.4G models.

Front Panel

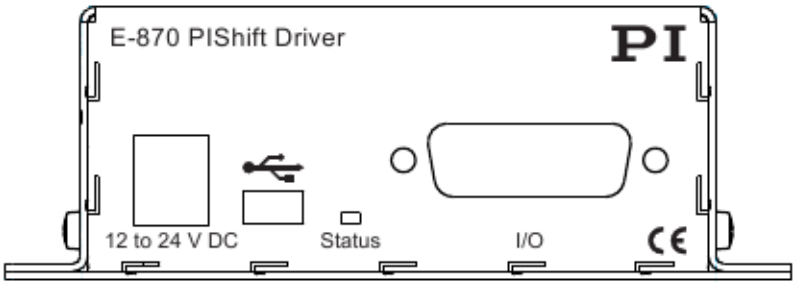


Figure 1: E-870.xG front panel

Labeling	Type	Function
12 to 24 V DC	Barrel connector socket	Connection for supply voltage
	Mini-USB type AB	USB 2.0 interface with "on-the-go" functionality, possible connections: ▪ PC for controlling the PIShift drive in step mode (command mode "Interface", see "Triggering Motions", (p. 17)) and for configuration of the E-870 (see "Drive Modes for PIShift Inertia Drives" (p. 14) and "Configuring the E-870 for the Connected Drive" (p. 22)) ▪ USB joystick for controlling the PIShift drive in step mode (command mode "Interface"), see "Triggering Motions" (p. 17)
Status	LED green/off	Display of the ready state: ▪ Green: the E-870 is ready for operation ▪ Off: the E-870 is not ready for operation
I/O	HD Sub-D 26-pin (f)	Connection options for: ▪ Configuration and control via digital and analog signals ▪ Reading out of status signals ▪ SPI master Details see "Pin assignment of I/O socket, HD Sub-D 26 (f)" (p. 9)

Rear Panel

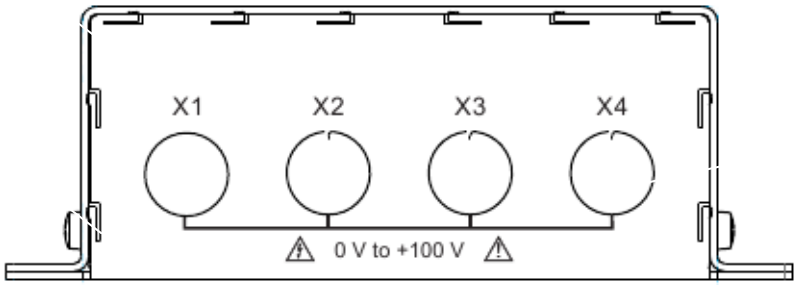


Figure 2: E-870.xG rear panel

Labeling	Type	Function
X1, X2, X3, X4	Mini-DIN sockets	For connection of PIShift drives*, **X2** only with E-870.2G, **X2** to **X4** only with E-870.4G, pin assignment see p. 11
	Warning sign	"Observe Technical Note!"
	Warning sign	"Risk of electric shock"
0 V to +100 V		Piezo voltage range: 0 to maximum 100 V

*Upon delivery, the piezo voltage range is 0 to 30 V. The piezo voltage range can be adjusted, see "Configuring the E-870 for the Connected Drive" (p 22).

Side View

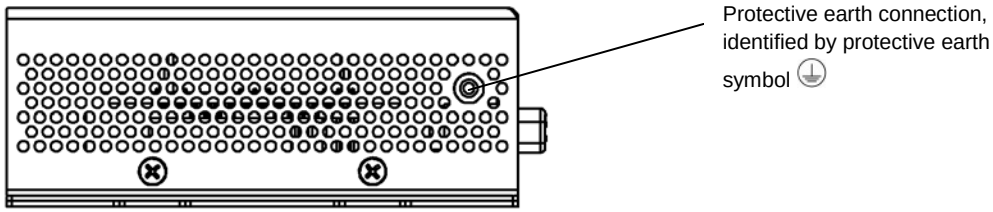


Figure 3: E-870.xG side view with protective earth connection

Pin Assignment

Pin assignment of I/O socket, HD Sub-D 26 (f)

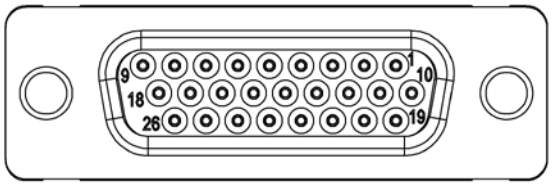


Figure 4: I/O socket, HD Sub-D 26 (f)

Pin No.	Signal	Function
1	SPI_MOSI Input	SPI interface, data input, see "SPI Interface" (p. 26)
2	SPI_CLK Input	SPI interface, CLK input, see "SPI Interface" (p. 26)
3	TEMPERATURE_OFL Output	Status display for overtemperature, TTL: ■ High[1]: temperature ≥ 70 °C ■ Low: temperature < 70 °C
4	RUN Output	Status display for the output of the piezo voltage, TTL: ■ High: piezo voltage is being output ■ Low: piezo voltage is not being output
5	CMD_MODE_0 Input	Selection of command mode to be used in step mode[3], least significant bit, TTL, see p. 17
6	CMD_MODE_1 Input	Selection of command mode to be used in step mode[3], bit 1, TTL, see p. 17
7	CMD_MODE_2 Input	Selection of command mode to be used in step mode[3], most significant bit, TTL, see p. 17
8	MUX_IN_0 Input	Selection of the active demultiplexer channel[3], least significant bit, TTL, see p. 19
9	MUX_IN_1 Input	Selection of the active demultiplexer channel[3], most significant bit, TTL, see p. 19
10	SPI_CS Input	SPI interface, Chip Select input, see "SPI Interface" (p. 26)
11	SPI_MISO Output	SPI interface, data output, see "SPI Interface" (p. 26)
12	ERROR Output	Error indicator, TTL: ■ High[2]: error (error code ≠ 0) ■ Low: no error

Pin No.	Signal	Function
13	DOUT Output	General digital output
14	PULSE_IN Input	Controlling the PIShift drive[4] in step mode (command modes "Digital Level Triggered", "Digital Edge Triggered" and "Digital Quadrature Decoder") TTL
15	DIRECTION_IN Input	Controlling the PIShift drive[4] in step mode (command modes "Digital Level Triggered", "Digital Edge Triggered" and "Digital Quadrature Decoder") TTL
16	GND	GND
17	ANALOG_IN Input	Controlling the PIShift drive[5] in step mode (command modes "Analog Linear" and "Analog Level Triggered") and in linear mode -10 to 10 V
18	GND	GND
19	GND	GND
20	NRESET Input	Reset of the E-870, LVTTL, active low
21	DIN_1	Reserved
22	DIN_2	Reserved
23	STOP Input	Stop the PIShift drive, TTL, active low
24	PIEZO_DRIVE_MODE_IN Input	Selection of the PIShift drive mode[3], TTL
25	GND	GND
26	5 V Output	5 V Max. output current 50 mA

[1] Overtemperature protection is active:

- Temperature of the board ≥ 70 °C: Output of piezo voltage is deactivated; automatic activation when the temperature has fallen to 65°C
- Temperature of the board ≥ 75 °C: E-870 is completely deactivated; reset of the E-870 necessary

[2]Indicates errors during the communication with the PC (USB interface) or the SPI master. The error code can be queried by sending the ERR? command either from the PC via USB or via the SPI master. The query sets the error code to zero and the line is switched to low.

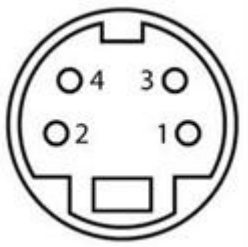
[3] The command mode for the step mode, the active demultiplexer channel and the PIShift drive mode can be selected by sending the relevant command from the PC via the USB interface or from the SPI master. If the selection is made via the PC or SPI master, the signals at pins 5, 6, and 7 and/or at pins 8, 9 and/or at pin 24 are ignored until the next time that the E-870 is reset.

[4] Is used in step mode (command modes "Digital Level Triggered", "Digital Edge Triggered" and "Digital Quadrature Decoder"), see "Drive modes for PIShift inertia drives“ (p. 14) and "Triggering motions" (p. 17).

[5] Is used in step mode (command modes "Analog Linear" and "Analog Level Triggered") and in linear mode, see "Drive modes for PIShift inertia drives“ (p. 14) and "Triggering motions" (p. 17).

Pin assignment of Mini-DIN 4 socket

Pin No.	Signal	Function
1	PIEZO- Output	Piezo voltage* for the PIShift drive
2	PIEZO+ Output	Piezo voltage* for the PIShift drive
3	n.c.	not connected
4	n.c.	not connected



* Upon delivery, the piezo voltage range is 0 to 30 V. The piezo voltage range can be adjusted, see "Configuring the E-870 for the Connected Drive" (p. 22). The maximum possible range is 0 to 100 V.

Accessories

Order Number	Description
E-709.02	HD Sub-D 26 (m) adapter cable with connector and open end, 1 m

Installation

Mounting the E-870

The E-870 can be used as a bench-top device or mounted in any orientation on a surface.

Tools and accessories

- Four M3 screws
- Suitable screwdriver

Mounting the E-870

1. Make the necessary holes in the surface. For the arrangement of the holes in the mounting rails of the E-870, see "Dimensions" (p. 30).
2. Mount the E-870 in the holes in the mounting rails with two suitable M3 screws on each side.

Connecting the E-870 to the Protective Earth Conductor

INFORMATION

➢ Observe the applicable standards for mounting the protective earth conductor.

Prerequisite

- You have read and understood the general notes on installation (see "Safety Measures during Installation", p. 4).
- The E-870 is switched off, i.e. the power supply is not connected to the power socket with the power cord.

Tools and accessories

- Suitable protective earth conductor:
  - Cable cross-section ≥0.75 mm²
  - Contact resistance <0.1 Ω at 25 A at all connection points relevant for mounting the protective earth conductor
- Fastening material for the protective earth conductor, sits on the protective earth connection in the following order upon delivery of the E-870, starting from the case:
  - Flat washer
  - Toothed washer
  - M4 screw
- Suitable wrench

Connecting the E-870 to the protective earth conductor

1. If necessary, fasten a suitable cable lug to the protective earth conductor.
2. Remove the M4 screw with toothed washer and flat washer from the protective earth connection of the E-870 (identified by the symbol for the protective earth conductor ⏚, see "Side View", p. 8).
3. Put the cable lug of the protective earth conductor, the toothed washer and the flat washer on the M4 screw in this order. In this way, the cable lug is wedged between the toothed washer and the screw.
4. Tighten the M4 screw with a torque of 1.2 Nm to 1.5 Nm.

Connecting the Power Supply to the E-870

Prerequisites

The power cord is **not** connected to the power socket.

Tools and accessories

- Included 24 V wide-range-input power supply (for line voltages between 100 and 240 VAC at 50 or 60 Hz)
- Alternatively: Sufficiently dimensioned power supply that provides 24 VDC with a maximum of 2.0 ampere
- Included power cord
- Alternatively: Sufficiently dimensioned power cord

Connecting the power supply to the E-870

- Connect the barrel connector of the 24 V wide-range-input power supply to the **12 to 24 V DC** connection of the E-870.
- Connect the power cord to the power supply.

Functional Principles

Drive Principle of the PIShift Inertia Drives

PIShift drives are space-saving and cost-effective piezo-based drives with a basically unlimited travel range. They make use of the stick-slip effect (inertia effect) – a cyclical alternation of static and sliding friction between a moving component and the piezo actuator generated by the piezo actuator – for a continuous feed of the component. The operating voltage is output as a modified sawtooth signal with a maximum frequency of 25 kHz.

The drive works silently at this frequency. When at rest, the drive is self-locking, requires no current and generates no heat. It holds the position with maximum force.

Drive Modes for PIShift Inertia Drives

The E-870 supports the following drive modes for PIShift inertia drives:

Operating Mode	Description
Step mode (default)	The E-870 generates, based on the specified number of steps and/or velocity, a modified sawtooth signal with a frequency of maximum 25 kHz and outputs the corresponding piezo voltage. The piezo voltage generates a cyclic alternation of static and sliding friction between the moving component and the piezo actuator and thus ensures a continuous feed of the moving component. The output of one period of the modified sawtooth signal generates one "step" of the moving component. The travel range is only limited by the physical limits of the drive. See "Triggering Motions" (p. 17) for the command modes for specifying the number of steps and the velocity.
Linear mode	The E-870 converts an analog input voltage "linearly" to an analog signal. The output piezo voltage corresponds to 10 times this analog signal. The feed of the moving component is generated by the expansion of the piezo actuator that is caused by the piezo voltage. The piezo actuator achieves its maximum expansion when the E-870 outputs the maximum permissible piezo voltage. The travel range is limited by the maximum expansion of the piezo actuator. See p. 19 for details on the analog input voltage.

Possibilities for selecting the PIShift drive mode:

- Via interface: Sending the MOD command from the PC (via USB, possible in the **E-870 Control** PC program) or from the SPI master
- Via the digital input line PIEZO_DRIVE_MODE_IN (pin 24 on HD Sub-D 26(f) I/O socket), see p. 16

If configuration is done via interface, the setting of the digital input is overwritten and ignored until the next time that the E-870 is reset.

Selecting the PIShift drive mode by sending the MOD command via an interface, shown here with the example of entering the command in the **E-870 Control** PC program:

1. In **E-870 Control**, change to the ***Command Entry*** tab.
2. Select the PIShift drive mode with the MOD command:
   - For selecting the step mode: Send
     MOD 1 3 0
   - For selecting the linear mode: Send
     MOD 1 3 1
3. Optional: Get the current setting of the PIShift drive mode. Send:
   MOD?
   Content of response:
   Line 1: active command mode for step mode (see p. 17)
   Line 2: active demultiplexer channel (see p. 19)
   Line 3: active PIShift drive mode (0 = step mode, 1 = linear mode)

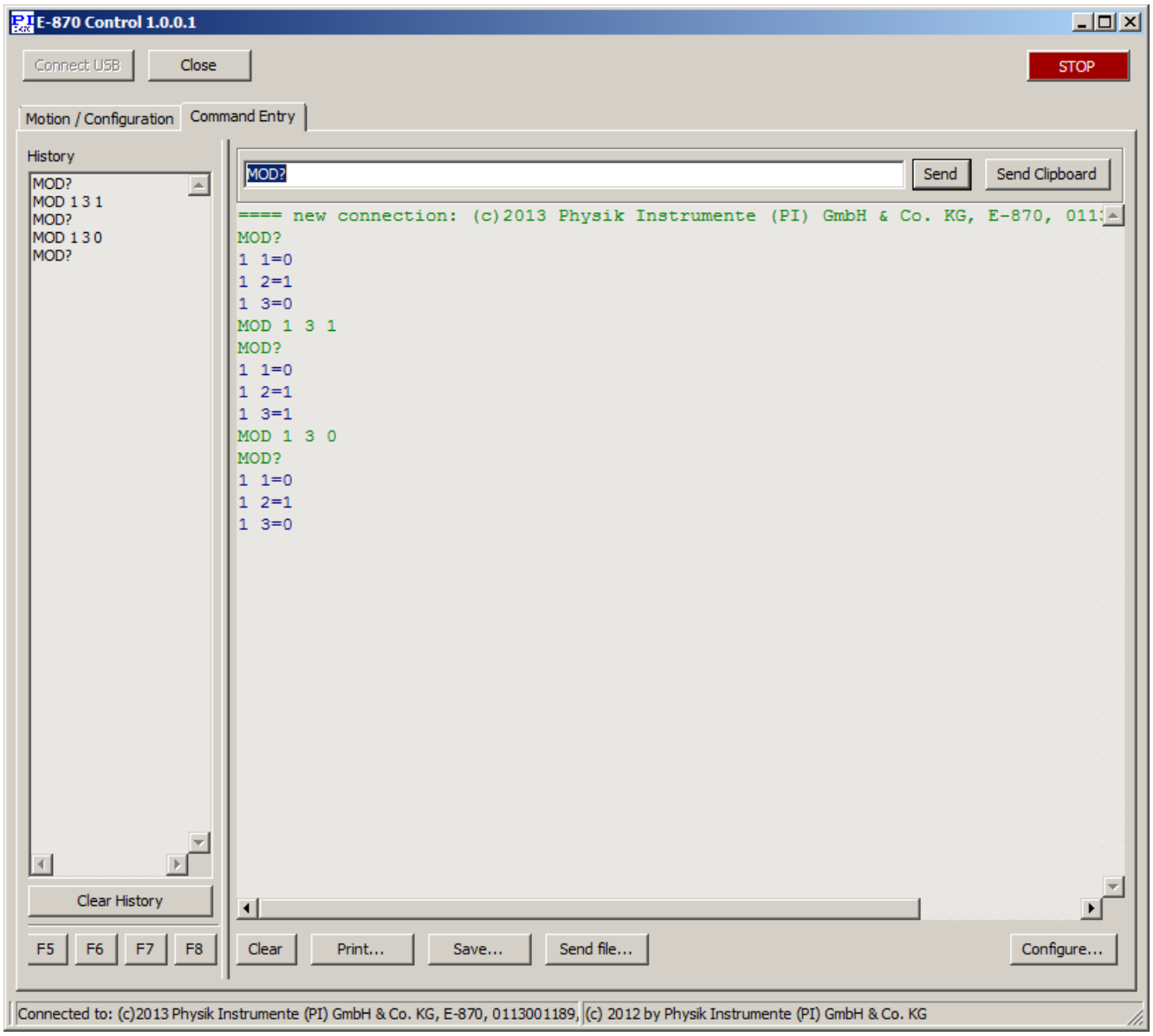


Figure 5: E-870 Control - selecting and getting the PIShift drive mode

Selecting the PIShift drive mode via digital input line (pin 24 of the HD Sub-D 26 (f) I/O socket, see "Pin Assignment" (p. 9)):

Function	Level of the Input Line
PIShift drive mode	**PIEZO_DRIVE_MODE_IN**
Step mode	OFF / LOW
Linear mode	ON / HIGH

Triggering Motions

The PIShift drive executes motions in step mode or in linear mode, for details see "Drive Modes for PIShift Inertia Drives", p. 14.

Step mode

The following command modes are available for step mode:

- "**Interface**" (mode 0):
  - PC (connected via USB): The **E-870 Control** PC software can be used to specify the number of steps to be traveled and the direction; the velocity (i.e. the current step frequency) is specified by a parameter and is constant
  - SPI master (connected via I/O socket): The SPI master can specify the number of steps to be travelled and the direction by sending the OSM command; the velocity (i.e. the current step frequency) is specified by a parameter and is constant. Example: Sending "OSM 1 200" starts 200 steps forwards, "OSM 1 -550" starts 550 steps backwards.
  - Joystick (connected via USB): the displacement of the joystick determines the velocity (i.e. the current step frequency) and the direction
- Pulse and Direction (TTL) digital input lines:
  - "**Digital Level Triggered**" (mode 1):
    Pulse: high = steps are executed, the velocity (i.e. the current step frequency) is specified by a parameter and is constant, low = no motion
    Direction: low = forwards, high = backwards
  - "**Digital Edge Triggered**" (mode 2):
    One step per rising signal edge on the Pulse line; direction is specified by the level of the Direction line, see above
  - "**Digital Quadrature Triggered**" (mode 3):
    For details see below
- Analog input line (-10 V to 10 V):
  - "**Analog Linear**" (mode 4):
    Value of the input voltage determines the velocity (i.e. the current step frequency), and the sign determines the direction (+ = forwards, - = backwards)
  - "**Analog Level Triggered**" (mode 5):
    Signal < -0.5 V or > 0.5 V = steps are executed, the velocity (i.e. the current step frequency) is specified by a parameter and is constant, signal between -0.5 and 0.5 V = no motion
    Sign of the signal: + = forwards, - = backwards

Details of the "Digital Quadrature Triggered" command mode:

- Steps forward:
  - Pulse positive edge + Direction low
  - Pulse negative edge + Direction high
  - Direction positive edge + Pulse high
  - Direction negative edge + Pulse low
- Steps backward:
  - Pulse positive edge + Direction high
  - Pulse negative edge + Direction low
  - Direction positive edge + Pulse low
  - Direction negative edge + Pulse high

Possibilities for selecting the command mode to be used in step mode:

- Via interface: Sending the MOD command from the PC (via USB, possible in the **E-870 Control** PC program via selection field or command input) or from the SPI master
- Via three digital input lines (on the HD Sub-D 26 (f) I/O socket; CMD_MODE_0 (pin 5), CMD_MODE_1 (pin 6), CMD_MODE_2 (pin 7)), see p. 19

If configuration is done via an interface, the settings of the digital inputs are overwritten and ignored until the next time that the E-870 is reset.

Selecting the command mode via PC in the corresponding selection field of the **E-870 Control** PC program:

1. In **E-870 Control**, change to the ***Motion / Configuration*** tab.
2. In the ***Current Command Mode*** field, select the command mode.

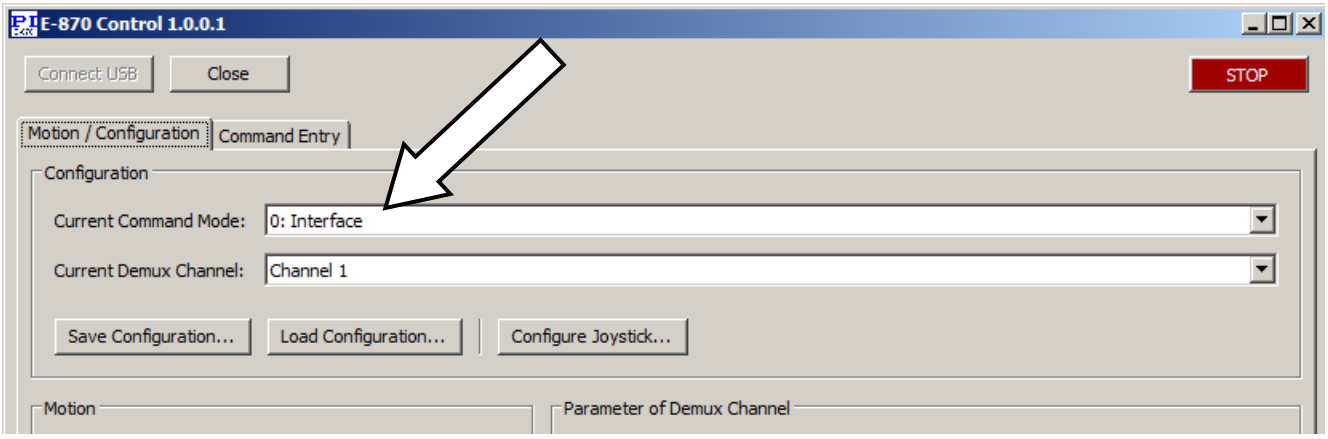


Figure 6: E-870 Control - selecting the command mode to be used in step mode

Selecting the command mode via direct command entry (via PC on the ***Command Entry*** tab in the **E-870 Control** PC program or via SPI master):

➢ Send the corresponding MOD command:

- For selecting "Interface": Send
  MOD 1 1 0
- For selecting "Digital Level Triggered": Send
  MOD 1 1 1
- For selecting "Digital Edge Triggered": Send
  MOD 1 1 2
- For selecting "Digital Quadrature Triggered": Send
  MOD 1 1 3
- For selecting "Analog Linear": Send
  MOD 1 1 4
- For selecting "Analog Level Triggered": Send
  MOD 1 1 5

Selecting the command mode via digital input lines (pins 5, 6 and 7 of the HD Sub-D 26 (f) I/O socket, see “Pin Assignment” (p. 9)):

Function	Level of the Input Line		
Command mode, details see p. 17	**CMD_MODE_0**	**CMD_MODE_1**	**CMD_MODE_2**
0 = Interface	OFF / LOW	OFF / LOW	OFF / LOW
1 = Digital Level Triggered	ON / HIGH	OFF / LOW	OFF / LOW
2 = Digital Edge Triggered	OFF / LOW	ON / HIGH	OFF / LOW
3 = Digital Quadrature Triggered	ON / HIGH	ON / HIGH	OFF / LOW
4 = Analog Linear	OFF / LOW	OFF / LOW	ON / HIGH
5 = Analog Level Triggered	ON / HIGH	OFF / LOW	ON / HIGH
6 = Reserved	OFF / LOW	ON / HIGH	ON / HIGH
7 = Reserved	ON / HIGH	ON / HIGH	ON / HIGH

Linear mode
The analog input voltage is connected to pin 17 of the HD Sub-D 26 (f) I/O socket (p. 9). The permissible voltage range amounts to a tenth of the permissible operating voltage range of the connected PIShift drive.

Example:

Permissible operating voltage range of the PIShift drive: 0 to 48 V
Permissible range of analog input voltage: 0 to 4.8 V

Demultiplexing

The E-870 supports one PIShift channel. The piezo voltage of the PIShift channel can be transferred to one of two (E-870.2G) or four (E-870.4G) demultiplexer channels, depending on the model. Up to two or four PIShift drives can be controlled serially in this manner. In contrast, the E-870.1G model can only control one drive.

Special parameter sets are available for the demultiplexer channels, so that the E-870 can be specifically adapted to each of the up to four inertia drives.

The settings can be stored in the nonvolatile memory of the E-870 (also refer to "Configuring the E-870 for the Connected Drive", p. 22), so that the configuration for the demultiplexer channels only has to be done once and only has to be repeated after a change of the drive. Thus the E-870 is optimally suited for operation without a PC.

Possibilities for selecting the demultiplexer channel:

- Via interface: Sending the MOD command from the PC (via USB, possible in the **E-870 Control** PC program via selection field, button or command input) or from the SPI master
- Via two digital input lines (MUX_IN_0 (pin 8), MUX_IN_1 (pin 9) on the HD Sub-D 26(f) I/O socket), see p. 19

If configuration is done via an interface, the settings of the digital inputs are overwritten and ignored until the next time that the E-870 is reset.

Selecting the active demultiplexer channel via PC in the **E-870 Control** PC program:

1. In **E-870 Control**, change to the ***Motion / Configuration*** tab.
2. Select the active demultiplexer channel. You have the following options:
   - ***Current Demux Channel*** field

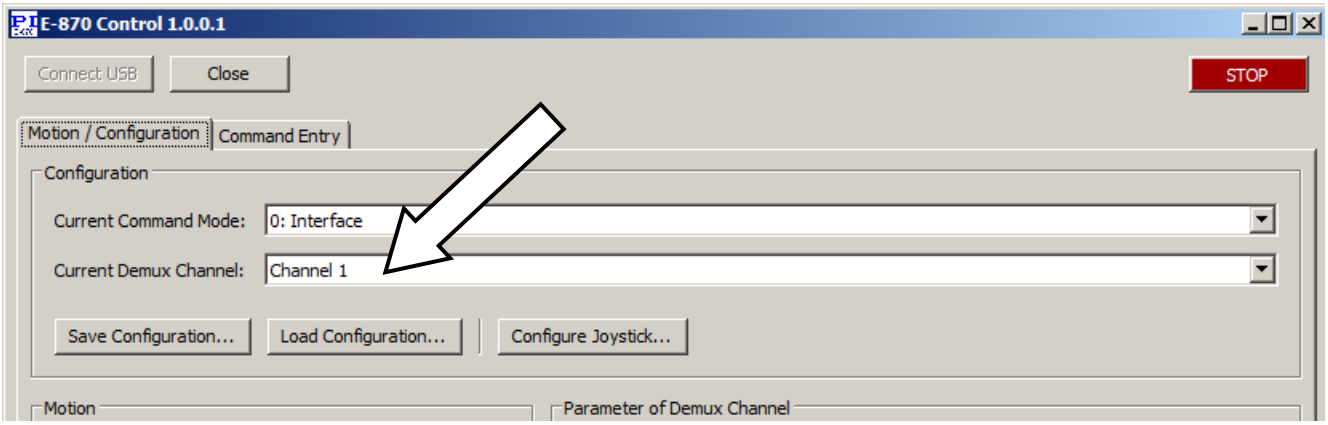


Figure 7: E-870 Control - selecting the active demultiplexer channel

   - ***Activate Channel*** buttons on the individual ***Channel*** tabs

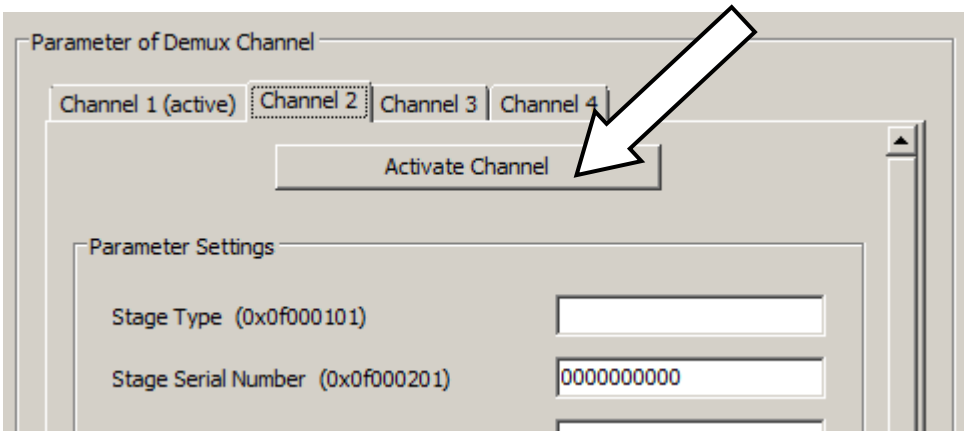


Figure 8: E-870 Control - selecting the active demultiplexer channel

Selecting the active demultiplexer channel via direct command entry (via PC on the ***Command Entry*** tab in the **E-870 Control** PC program or via SPI master):

➢ Send the corresponding MOD command:

- For selecting channel 1: Send
  MOD 1 2 1
- For selecting channel 2: Send
  MOD 1 2 2
- For selecting channel 3: Send
  MOD 1 2 3
- For selecting channel 4: Send
  MOD 1 2 4

Selecting the active demultiplexer channel via digital input lines (pins 8 and 9 of the HD Sub-D 26 (f) I/O socket, see “Pin Assignment” (p. 9)):

Function	Level of the Input Line	
Active demultiplexer channel	**MUX_IN_0**	**MUX_IN_1**
1	OFF / LOW	OFF / LOW
2	ON / HIGH	OFF / LOW
3	OFF / LOW	ON / HIGH
4	ON / HIGH	ON / HIGH

Configuring the E-870 for the Connected Drive

During initial start-up of the E-870, it is necessary to adjust the operating parameters to the connected drive type. Then the parameters only have to be adapted when the connected drive type is changed. For suitable parameter values refer to the documentation of the drive.

INFORMATION

- Adjust parameters with the **E-870 Control** PC program.
- If you have to adjust the parameters via the SPI master, contact our customer service department for the corresponding command descriptions.

Adaptation of the parameters with the **E-870 Control** PC program: The PC must be connected to the E-870 via the USB interface. Proceed as follows:

1. In **E-870 Control**, change to the ***Motion / Configuration*** tab.
2. In the ***Parameter of Demux Channel*** pane, change to the tab of the active demultiplexer channel.
3. On the tab of the active demultiplexer channel, enter suitable values for the operating parameters.

   For entering values, please note:

   - If you are prompted to enter a password, enter the password *advanced*.
   - After entering a value, press the Enter key of the PC keyboard to transfer the value to the volatile memory of the E-870. In doing so, the entry in the input field changes its color from blue to black.

   Parameters to be entered for identifying the drive:

   - ***Stage Type***: Name of the PIShift drive
   - ***Stage Serial Number***: Serial number of PIShift drive, can be read on the case of the drive

   Parameters to be entered for the motion of the drive:

   - ***PIShift Upper Supply Voltage***: Upper limit of the operating voltage of the PIShift drive, unit V
   - ***PIShift Lower Supply Voltage***: Lower limit of the operating voltage of the PIShift drive, unit V
   - ***PIShift Frequency***: Operating frequency of the PIShift drive, unit Hz
   - ***PIShift Steps per Second***: Number of steps traveled by the PIShift drive per second with the set operating frequency, unit Hz. The value for the number of steps per second may not be greater than the value for the operating frequency.
   - ***PIShift Charge Cycle***: Duty cycle of the current source during the output of one period of the modified sawtooth signal in step mode, without unit
   - ***PIShift Forward Current***: Charging current during forward motion, unit A
   - ***PIShift Backward Current***: Charging current during backward motion, unit A

4. In the ***Motion*** pane, start a few motions of the PIShift drive:
   a. In the ***Number of Steps*** field, enter the largest possible number of steps.
   b. Start a forward motion of the PIShift drive with the [>] button.
   c. Start a backward motion of the PIShift drive with the [<] button.
   d. Stop the motion with the ***STOP*** button.
5. If necessary: Optimize the values for the charging current of the drive (***PIShift Forward Current*** and ***PIShift Backward Current***).

   Optimizing the values can be necessary due to production-related tolerances. Test the charging current as follows:

   – Start the forward motion and, during the motion, compare the value of the ***Upper Step Voltage of Driver (VOLTS)*** status display (in the ***State*** pane) with the value of ***PIShift Upper Supply Voltage***. Then stop the motion.
   – Start the backward motion and, during the motion, compare the value of the ***Lower Step Voltage of Driver (VOLTS)*** status display (in the ***State*** pane) with the value of ***PIShift Lower Supply Voltage***. Then stop the motion.

   The charging current is optimally set if the following applies:

   – During the forward motion, the value of ***Upper Step Voltage of Driver (VOLTS)*** is equal to ***PIShift Upper Supply Voltage*** or maximally 5 % greater.
   – During the backward motion, the value of ***Lower Step Voltage of Driver (VOLTS)*** is equal to ***PIShift Lower Supply Voltage*** or maximally 5 % greater.

   If the charging current is **not** optimally set:

   a. Enter a new value for the charging current for the direction of motion concerned.
   b. Test the charging current again.
6. Save the new values in the nonvolatile memory of the E-870:
   – On the tab of the active demultiplexer channel, click on the ***Save As Default (EEPROM)*** button.

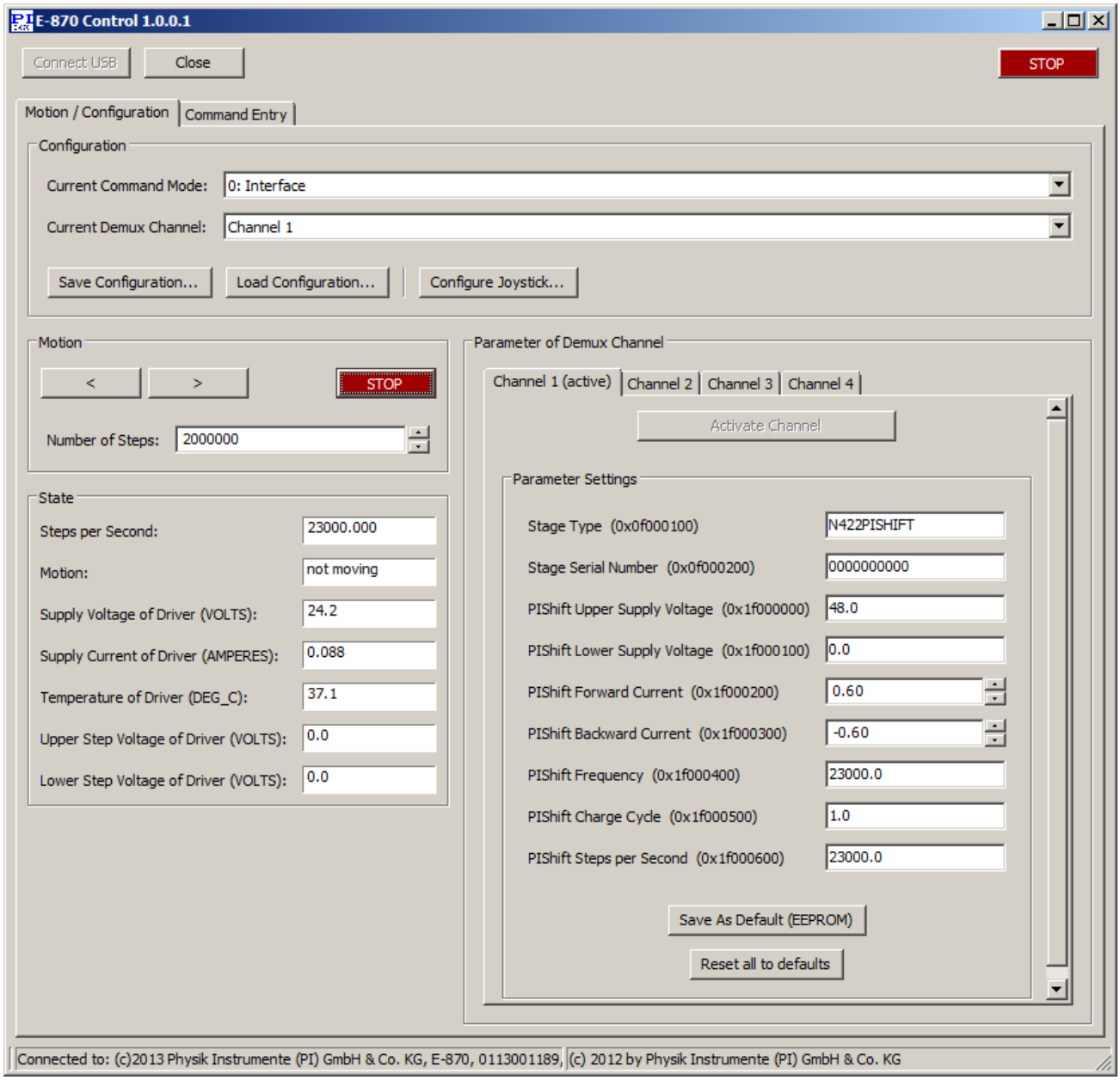


Figure 9: Example: E-870 Control - operating parameters for N-422

Status Displays in E-870 Control

The following status displays — in addition to those described in "Product View", p. 6, or "Pin Assignment", p. 9, — are available in the **E-870 Control** PC program:

- Current supply voltage
- Current power consumption
- Temperature of the amplifier
- Current highest output voltage
- Current lowest output voltage

The status displays can also be queried by sending the DIA? command from the PC (via USB) or from the SPI master. The identifiers of the valid query categories for the E-870 can be identified by sending the HDI? command (important for interpreting the response to DIA?).

SPI Interface

General Information

The SPI interface of the E-870 is intended for sending commands of the PI General Command Set (GCS). In the "Interface" command mode, the E-870 can be configured, controlled and monitored via an SPI master using GCS commands.

INFORMATION

- Get the GCS commands supported by E-870 in a convenient way by connecting the E-870 and PC via USB and sending the HLP? command in the **E-870 Control** PC program.
- Descriptions of the GCS commands can be found in the document PIGCS_2_0_DLL_SM151E200.pdf (manual of the dynamic program library) on the product CD of the E-870.

The E-870 can be integrated in a controller with position control, for example, by using the SPI interface.

Signals

The SPI interface has 4 data signal lines. The E-870 is configured as a slave. All data transmissions are therefore controlled (started and stopped) by the external master.

For the SPI interface, the signals and the pin assignment of the HD Sub-D 26 (f) I/O socket are listed in the table below.

Signal	Description	In/Out E-870	Level	Pin No.
SPI MOSI	SPI Master Out Slave In data signal	In	TTL / LVTTL	1
SPI CLK	SPI Clock Signal	In	TTL / LVTTL	2
SPI MISO	SPI Master In Slave Out data signal	Out	5V TTL	11
SPI CS	SPI Chip Select signal	In	TTL / LVTTL	10
SPI GND	Ground		GND	19

Data Transmission and Clocking Scheme

The GCS commands are transmitted via the SPI interface in 8-bit ASCII data sets.
The E-870 (slave) outputs its data on SPI MISO with the rising edge of the CLK signal and reads the data from the SPI master on SPI MOSI with the falling edge of the CLK signal. The SPI master writes and reads according to the same principle. The data is transmitted with the most significant bit first (MSB first).

The SPI master should poll the slave for new data with a fixed update rate. This is the only way for the E-870 to send data to the master. Each sent data byte within an SPI data frame contains one ASCII character.
If there is no further new data on the SPI master that has to be sent to the slave, the master cyclically sends dummy bytes with the binary value 0x00. The slave then ignores all input data with this value. The slave can continue to send its data to the master, however.
If the slave does not have any other new data that has to be sent either, then it also sends dummy bytes with the code 0x00. Bytes with the code 0xFF are also interpreted as dummy bytes.

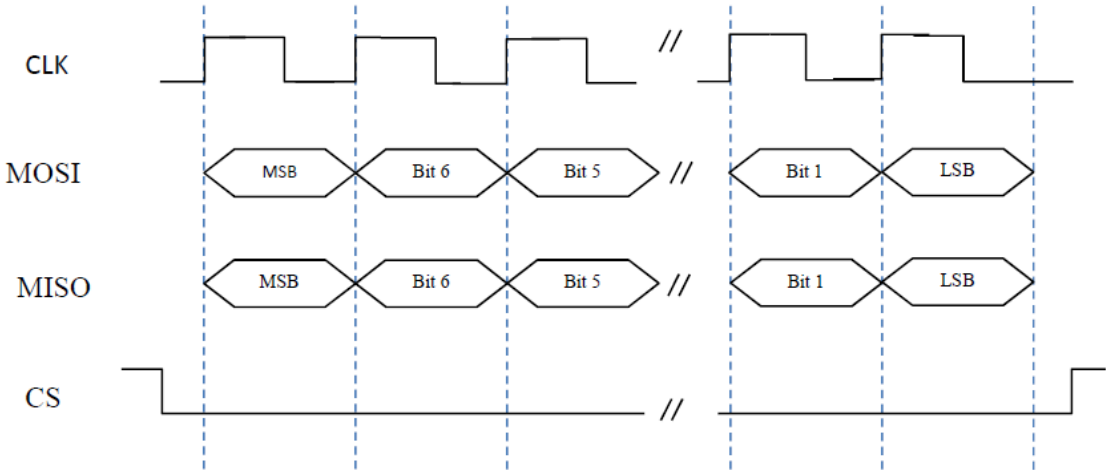


Figure 10: Example of the transmission of a single byte

The table below shows the timing requirements of the SPI interface.

Description / Timing	**MIN**	**MAX**
Cycle time (SPI CLK period), Tc	-	100 ns
Delay time, MISO valid after rising CLK edge	-	27 ns
Setup time, MOSI before falling CLK edge	0 ns	-
Valid time, MOSI valid after falling CLK edge	1 ns	-
CS active time before rising CLK edge	Tc	-
CS active time before falling CLK edge	Tc	-
Data update rate (normal mode)	-	150 kBytes/s
Maximal SPI frame rate (normal mode)		10 kHz
Maximal SPI frame rate during flash operation		50 Hz
Date update rate during flash operation		2.5 kBytes/s

Technical Data

Specifications

Preliminary data	E-870.1G	E-870.2G	E-870.4G
Function	Drive electronics for PIShift linear drives, bench-top device		
Channels	1	2 serial control through demultiplexing	4 serial control through demultiplexing
Amplifier			
Amplifier channels	1	1, serial control of 2 axes with demultiplexing	1, serial control of 4 axes with demultiplexing
Output voltage	0 to 100 V		
Peak output power	30 W		
Output current / channel (<5 ms)	±650 mA		
Interfaces and operation			
Communication interfaces	USB 2.0; SPI		
Actuator connection	Mini DIN 4-pin		
Analog and digital inputs	Analog ±10 V, 10 Bit ADC, 12 TTL inputs for sending commands and for configuration		
Digital output	Overtemperature protection indicated at 75 °C, operating status and error output		
Command set	PI GCS 2		
User software	Configuration and operation tool: E-870 Control		
Software drivers	LabVIEW driver, dynamic libraries for Windows		
Supported functionality	Full-step mode (default), linear mode (analog control); alternative command modes: pulse-controlled, pulse edge-controlled, quadrature decoder control, analog velocity control		
Display	LED display for operation		
Manual control	Joystick via USB		
Miscellaneous			
Operating temperature range	0 to 50 °C		

Preliminary data	**E-870.1G**	**E-870.2G**	**E-870.4G**
Overtemp protection	Deactivation at 75°C		
Mass	310 g	330 g	340 g
Operating voltage	12 to 24 V (power supply included in the scope of delivery)		
Max. power consumption	35 W		

Dimensions

Dimensions in mm. Note that the decimal places are separated by a comma in the drawings.

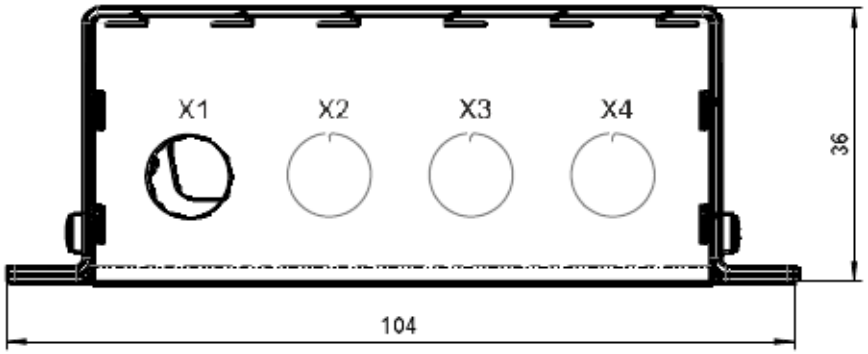


Figure 11: E-870.xG dimensions

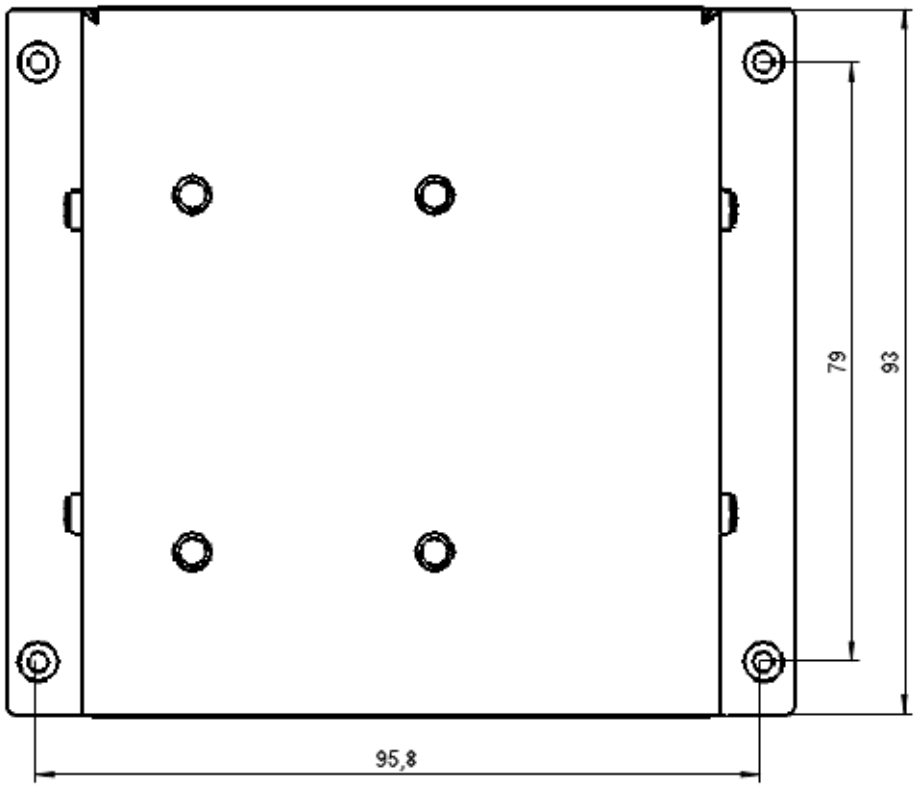


Figure 12: E-870.xG dimensions, mounting rails with M3 holes