PZ167E User Manual

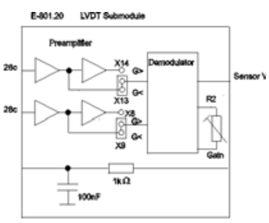
E-625 LVPZT Controller/Amplifier

Release: 1.3.0 Date: 2007-06-22

This document describes the following product(s):

- E-625.SR
  LVPZT Controller/Amplifier, Single Channel, for Strain Gauge Sensors
- E-625.LR
  LVPZT Controller/Amplifier , Single Channel, for LVDT Sensors

All models with servo-control and computer interface and command interpreter submodules as standard



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Declaration of Conformity

according to ISO / IEC Guide 22 and EN 45014

Manufacturer:	**Physik Instrumente (PI) GmbH & Co. KG**
Manufacturer´s Address:	Auf der Römerstrasse 1 D-76228 Karlsruhe, Germany

The manufacturer hereby declares that the product

Product Name:	**LVPZT Controller/Amplifier**
Model Numbers:	**E-625**
Product Options:	**all**

complies with the following European directives:

73/23/EEC, Low-voltage Directive
89/336/EEC, EMC Directive

The applied standards certifying the conformity are listed below:

Electromagnetic Emission:	EN 61000-6-3, EN 55011
Electromagnetic Immunity:	EN 61000-6-1
Safety (Low Voltage Directive) :	EN 61010-1

December 23, 2005
Karlsruhe, Germany

Dr. Karl Spanner
President

About This Document

Users of This Manual

This manual is designed to help the reader to install and operate the E-625 LVPZT Controller/Amplifier. It assumes that the reader has a fundamental understanding of basic servo systems, as well as motion control concepts and applicable safety procedures.
The manual describes the physical specifications and dimensions of the E-625 LVPZT Controller/Amplifier as well as the hardware installation procedures which are required to put the associated motion system into operation.
This document is available as PDF file on the product CD. Updated releases are available for download from www.pi.ws or via email: contact your Physik Instrumente Sales Engineer or write info@pi.ws.

Conventions

The notes and symbols used in this manual have the following meanings:

WARNING

Calls attention to a procedure, practice or condition which, if not correctly performed or adhered to, could result in injury or death.

DANGER

Indicates the presence of high voltage (> 50 V). Calls attention to a procedure, practice or condition which, if not correctly performed or adhered to, could result in injury or death.

CAUTION

!

Calls attention to a procedure, practice, or condition which, if not correctly performed or adhered to, could result in damage to equipment.

NOTE

Provides additional information or application hints.

Related Documents

The hardware components and the software tools which might be delivered with E-625 LVPZT Controller/Amplifiers are described in their own manuals. All documents are available as PDF files on the product CD. Updated releases are available via FTP or email: contact your Physik Instrumente sales engineer or write info@pi.ws.

E-801 User Manual, PZ117E
E-802 User Manual, PZ150E
E-816 User Manual, PZ116E
E-816 DLL Software Manual, PZ120E101E
E-816 LabVIEW Software Manual, PZ121E
Analog Controller LabView Driver Library Software Manual, PZ181E
PZTControl Software Manual, PZ146E

Contents

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1 Introduction

1.1 Prescribed Use

Based on their design and realization, E-625 LVPZT Controller/Amplifiers are intended to drive capacitive loads, in the present case, piezoceramic actuators. The E-625 must not be used for applications other than stated in this manual, especially not for driving ohmic (resistive) or inductive loads. E-625s can be operated in closed-loop mode using capacitive position sensors. Appropriate sensors are provided by PI and integrated in the mechanics according to the mechanics product specifications. Other sensors may be used as position sensors only with permission of PI.

Observe the safety precautions given in this User Manual.

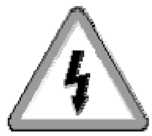
E-625s conform to Measurement Category I (CAT I) and may not be used for Measurement Categories II, III or IV. Other use of the device (i.e. operation other than instructed in this Manual) may affect the safeguards provided.

E-625s meet the following minimum specifications for operation*:

- Indoor use only
- Altitude up to 2000 m
- Ambient temperature from 5°C to 40°C
- Relative humidity up to 80% for temperatures up to 31°C, decreasing linearly to 50% relative humidity at 40°C
- Line voltage fluctuations of up to ±10% of the line voltage
- Transient overvoltages as typical for public power supply
  Note: The nominal level of the transient overvoltage is the standing surge voltage according to the overvoltage category II (IEC 60364-4-443).
- Degree of pollution: 2

* Any more stringent specifications in the Technical Data table are, of course, also met.

1.2 Safety Precautions



DANGER

Read This Before Operation:

E-625 LVPZT Controller/Amplifiers generate voltages up to 120 V for driving LVPZTs. The output power may cause serious injury.

When working with these devices or using PZT products from other manufacturers we strongly advise you to follow general accident prevention regulations.

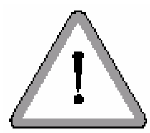
All work done with and on the equipment described here requires adequate knowledge and training in handling High Voltages. Any cabling or connectors used with the system must meet the local safety requirements for the voltages and currents carried.

Be sure to connect the ground stud on the rear panel to a Protective Ground!

Procedures which require opening the case should be carried out by authorized, qualified personnel only.

Disconnect unit from power when opening the case, and when resetting internal switches or jumpers.

When the unit must be operated with the case open, voltages of up to 120 V can be exposed. Do not touch internal conductors.



WARNING

Connect the AC power cord of the external power supply to the wall socket (100 to 240 VAC).

To disconnect the system from the supply voltage completely, remove the power plug from the wall socket.

Install the system near the AC outlet and such that the AC power plug can be reached easily.

!

CAUTION

Place the system in a location with adequate ventilation to prevent internal heat build-up. Allow at least 10 cm (4 inches) clearance from the top and the rear of the unit and 5 cm (2 inches) from each side.

1.3 Unpacking

Unpack the E-625 LVPZT Controller/Amplifier with care. Compare the contents against the items ordered and against the packing slip. The following items should be included:

- Controller unit (E-625)
- Separate power supply (E-661.PS, 15 V)
- Line-power cable
- RS-232 null-modem cable for PC connection (C-815.34)
- SMB/BNC adapter cables (E-692.SMB) 1.5m, two units
- User Manual for E-625 (PZ167E), this document
- User Manual for E-816 Computer Interface and Command Interpreter Submodule (PZ 116E)
- User Manual for E-802 Servo-Control Submodule (PZ 150E)
- User Manual for E-801 Sensor Excitation and Readout Submodule (PZ 117E)
- CD for E-816-interface devices with software and documentation (E-816.CD)

Inspect the contents for signs of damage. If parts are missing or you notice signs of damage contact PI immediately.

Save all packing materials in the event the product needs to be shipped elsewhere.

2 Description

2.1 Model Survey

E-625 amplifier/controllers are designed as stand-alone desktop devices. Networking of E-625's with each other or with other devices equipped with the E-816 submodule allows controlling up to 12 devices over a single RS-232 computer interface. Networking requires additional wiring and setup.

The following models are described in this manual; each supports a different position-sensor type. All models come with an E-802 Servo-Controller and an E-816 Computer Interface and Command Interpreter installed as standard.

E-625.LR LVPZT controller offering RS-232 and I^2C interfaces for computer control and networking, an amplifier, sensor supply (AC excitation) and processing circuit including preamplifier, demodulator, different filters and a proportional-integral (P-I) servo-controller. The units can be operated in both open-loop and closed-loop modes and are mainly used with LVDT sensors.

E-625.SR Same as the E-625.LR but with DC sensor excitation and readout circuitry (for strain gauge sensors only).

E-625.SR and E-625.LR controllers are designed to drive and control the displacement of low-voltage piezoelectric actuators (LVPZT) with SGS or LVDT position feedback sensors. The E-625.CR, designed for operation with capacitive feedback sensors, is described in a separate manual.

2.2 Functionality

The E-625 features a single-channel power amplifier with an average output power of 6 watts. The design is based on a power amplifier (voltage source), optimized for driving capacitive loads. The units also have provision for position sensor excitation and readout, servo-control logic, and computer control with multi-axis networking. These last three functions are implemented on small PCB submodules. The submodules are generally ordered with the system and come already installed, though they can be replaced by the user. The block diagram on p. 30 answers most questions about how the various elements interact with each other.

Basic operation involves the user commanding a motion and the E-625 supplying the required voltage on the PZT output line for the PZT to execute the commanded motion. The motion command can be either a string of ASCII characters delivered over the computer-control interface (computer-controlled operation) or a voltage, perhaps computer generated, on the analog input line (referred to as analog operation in this manual). Furthermore, the motion command can specify either a target position (i.e. closed-loop = servo ON = position-controlled mode), or a target voltage for the PZT (i.e. open-loop = servo OFF = voltage-controlled mode). The various combinations of operating mode are shown in the table below:

Type of Operation / Servo Mode	Computer-Controlled[1] Operation Commanded values are specified in ASCII commands originating in a host PC	Analog Operation[2] Commanded values are specified by putting a voltage on the Analog Input terminal
Servo OFF (open-loop or voltage-controlled mode) Position sensor output is available but not used internally	Only voltage-setting motion commands are executed	Input voltage is translated directly into a voltage to be applied to the PZT output. The E-625 acts like a linear amplifier
Servo ON (closed-loop or position-controlled mode)[2] Position sensor output is used by the servo-control loop to assure that target position is reached	Only position-setting motion commands are executed; the servo-control loop is used to effectuate the moves	Input voltage is interpreted as a target position for the PZT. The servo-control loop is used to effectuate the move.
[1]Computer control and networking functions are implemented on a factory-installed plug-in submodule (E-816) and are described in detail in a separate manual. Operating the unit with a computer-generated analog signal is considered under Analog Operation. [2]Servo-control logic, a notch filter and slew rate limitation are all implemented on an included plug-in submodule (E-802) which is described in detail in a separate manual. Note that with the E-802.55 version, the notch filter and slew rate limiter are active even when the submodule sees the servo-off signal. This can cause PZT voltage changes in open-loop when the notch filter frequency is changed.		

Table 1: E-625 Operating Modes. See below for details.

The voltage required for analog operation can be generated by a data acquisition card (DAQ) in a PC. PI now offers a LabVIEW driver set that supports this operating mode. Note that the servo must be on when working with this driver set. With it, you can use the familiar commands of the PI General Command Set in your LabVIEW environment to command the device via the analog input. Documentation on the PI LabVIEW driver set supporting that operating mode, including the Hyperbit™ drivers which make possible position resolution higher than that of the DAQ board used, is on the included E-816 CD. Installation of the LabVIEW Analog Driver set is a

Setup option. New releases are available from the download area at www.pi.ws. See the included E500T0011 Technical Note for instructions. For the Hyperbit™ extension contact your PI Sales Engineer.

Most users will be using the computer-controlled operating modes. It is possible to command up to twelve E-625s over a single RS-232 interface from a single host PC. The E-625 connected to the RS-232 link (the master) relays commands to the other units (slaves) on the network. Responses from the slaves are then relayed by the master back to the PC. Networking E-625s requires proper setup of each unit and busing of network connector lines 7, 8 and a GND, with multiple E-625s also requiring busing of lines 3 and 4 among them.

PI also supplies software to run on the host PC controlling the E-625(s). Included are LabView drivers, a COM Server, a DLL Library and the *PZTControl* graphic user interface software.

Computer control and networking are implemented with the E-816 plug-in submodule, which is included in the standard configuration. See the *E-816 User Manual* for details.

The information in this manual, while primarily for those using computer-controlled operation, is also valid for analog operation. Keep in mind that for analog operation, “commanded” or “target” position or voltage refers to the position or voltage associated with the *voltage* put on the analog input terminal in conjunction with the position of the DC-offset potentiometer (if installed and activated). If the unit is in servo-control mode, the voltage on the analog input terminal will be interpreted as a position. In analog operation the servo-control loop can be activated by shorting pins or jumpers. In computer-controlled operation the servo-control loop can be activated by command. See Operating Modes, p. 12 or refer to the block diagram on p. 30 for details.

Using servo-control mode with a position sensor is the most efficient way to suppress errors due to hysteresis, creep and load variation; the piezo translator can then be controlled with an accuracy that is determined by the accuracy of the sensor used. The type of position-control sensor used must be compatible with the E-625 model to which it is attached: in particular linear variable differential transformers (LVDT) require the AC excitation provided by the E-625.LR. The sensor electronics submodules are described in detail in the “E-801 Sensor Processing Submodule” section, starting on p. 34 of this manual.

The maximum output voltage range of the power amplifier is from -20 to +120 V, so as to support the full extension capability of PI low-voltage PZT translators. For maximum PZT lifetime, excursions above 100 V and below -10 V should be kept as short and as infrequent as possible.

E-625 controllers can be used for both static and dynamic applications. High output stability and low noise assures stable micropositioning. Because LVPZT translators have high capacitances, the integrated amplifier is designed to supply appropriately high peak currents for dynamic applications. Excellent linearity and stability allows the use of E-625 controllers in precision measurement and control systems.

3 Quick Start

1. Connect the E-625 to its external power supply (order# E-661.PS, included), and connect the power supply to the line voltage.
2. Make the hardware settings required for the operating mode you wish to use. See Operating Modes, p. 12 for details.
   Note: The servo must be on for analog operation, when you want to work with a computer-generated signal (e.g. from a DAQ board) and the analog LabVIEW driver set from PI (see step 6 below).
3. Connect the piezo stages/actuators to the proper E-625 units. If your system was calibrated by PI, the controllers and stages are not interchangeable. The serial numbers of the corresponding stages should be marked on calibration labels on the controller.
4. Switch on the power supply.
5. If you will be using computer-controlled operation, continue now with the instructions in “Starting Operation” in the E-816 Computer Interface Submodule User Manual. It will lead you through installation of the host software and, if necessary, configuring unique axis identifiers in a multi-axis system. That manual also contains an overview of the included software.
6. If you will be using analog operation and generating the analog signal with a DAQ board in a PC running LabVIEW and using PI’s LabVIEW Analog Driver Set, install that driver set. It can be installed by running Setup on the included E-816 CD or downloaded from www.pi.ws. See the included E500T0011 Technical Note for detailed download instructions, and the driver documentation for operation.

4 Operating Modes

As already mentioned, the E-625 supports analog and computer-controlled operation. In analog operation, the PZT is controlled by the voltage of an analog signal on the analog input line in combination with the position of an (optional) offset potentiometer (if installed and activated). In computer-controlled operation, the PZT is controlled by ASCII commands originating in a host PC.

NOTE

Controlling the E-625 with a computer-generated analog signal (e.g. DAQ board) is treated in this manual as "Analog Control," not "Computer Control."

Note that only the DIP switch block S1 and the Zero potentiometer are accessible without opening the case. To access other adjustment elements (e.g. jumpers), it is necessary to remove the top cover. See Section 7 on p. 20 for more information.

4.1 Computer-Controlled Operation

Select computer-controlled operation by setting DIP switch 2 (on block S1) to ON (down) and switch 1 (on left) to OFF. Make sure jumper J1 is in position 2-3 if you wish to use servo-control, the notch filter or slew rate limitation. In computer-controlled operation, many settings (such as servo mode) can be configured to be controllable by command. See the *E-816 Computer Interface and Command Interpreter User Manual* for details.

4.2 Analog Operation

In analog operation, the voltage output to the PZT is controlled by the analog input. The analog input is accepted on the corresponding front-panel connector if DIP switches 2 and 4 are OFF and sw. 1 is ON (see block diagram, p. 30) The nominal input voltage range is 0 to +10 V for a 0 to 100 V output voltage swing. For some applications, where the full expansion capability of the piezo translators is needed, the full output voltage range of -20 to +120 V can be used. The equivalent input voltage range is then -2 to +12 V.

4.3 Open-Loop Operation (Voltage-Controlled, Servo Off)

In open-loop mode (voltage-controlled operation), the position servo-control portion of the E-802.5x submodule circuitry (E-802.5X) is deactivated. With E-802.55 version submodules, the slew rate limitation and notch filter remain active (unless, of course, jumper J1 is in position 1-2). In computer-controlled operation, when servo-mode is OFF, only voltage-setting commands are accepted. In analog operation the system works like a linear amplifier with the PZT operating voltage proportional to the control signal input plus offset. (The sensor electronics works independently, and outputs the current piezo position even in open-loop mode, provided a sensor is properly connected. Since there is some variation among different PZTs of the same model, the voltage required to bring the PZT to its nominal expansion will differ.)

4.4 Closed-Loop Operation (Position-Controlled, Servo ON)

Position-controlled (Servo ON) operation offers both drift-free and hysteresis-free positioning as well as immunity to load variations. To enable the position-controlled mode:

- In computer-controlled operation, use the SVO command; note that jumper J1 must be in position 2-3.
- In analog mode, set sw 3 of DIP block S1 to ON; note that jumper J1 must be in position 2-3.

In position-controlled mode, the servo-control electronics decide what voltage should be output to the PZT based on the commanded position. The operating voltage for the PZT will remain in the range from -20 to +120 V. If the actual expansion of the PZT cannot match that defined by the control signal, an active-low TTL signal on internal connector pin 26a causes the yellow Overflow LED to light.

PI's standard calibration procedure assures that that the PZT reaches its nominal expansion when that position is commanded (in analog mode, when the input control signal is +10 V). Note that due the variation in PZTs, the voltage output to the PZT will not be exactly 100 V.

In position-controlled mode, it is the output of the proportional-integral (P-I) servo-controller that is used as input to the amplifier. The piezo voltage is adjusted until the final target position is reached. In this mode, the relationship between target position and PZT supply voltage may not be linear.

5 Installation

DANGER

Read This Before Operation:

E-625 LVPZT Controller/Amplifiers generate voltages up to 120 V for driving LVPZTs. The output power may cause serious injury.

When working with these devices or using PZT products from other manufacturers we strongly advise you to follow general accident prevention regulations.

All work done with and on the equipment described here requires adequate knowledge and training in handling High Voltages. Any cabling or connectors used with the system must meet the local safety requirements for the voltages and currents carried.

Be sure to connect the GND stud on the rear panel to a protective ground!

5.1 Preparing for Operation

If PI had sufficient knowledge of your application and you ordered your system components together, they will be preinstalled and preconfigured. In that case you only need to perform the steps shown in bold below. All operations on the E-625 board and or the submodules—i.e. setting jumpers, potentiometers or switches—require opening the case and are to be carried out by qualified authorized personnel only.

DANGER

Disconnect the E-625 from its power supply before opening the case.

1. Set the switches and jumpers on the submodules in the E-625 as required for your application; (for the sensor excitation/readout submodule, see p. 34, for the servo-control and computer interface submodules see the respective user manuals)[1].

[1] This requires opening the case.

2. Set the switches on the E-625 front panel and the jumpers on the main board as required for your application (see p. 21)[2].

3. Connect the positioner(s) and sensors to the E-625. In precalibrated multi-axis systems, the serial numbers of the corresponding controller/positioner pairs are marked and must be respected.

4. Connect the grounding stud on the rear panel to a protective ground.

5. Power up the E-625 (see p. 34 for power supply specifications) and the host computer.

6. Connect host computer to the E-625 using the RS-232 cable.

7. Start the interface software (e.g. PZTControl; for RS-232 interface settings see the E-816 User Manual). Send a command that gives a response (e.g. *IDN?). If no response arrives, check that the host software baud rate setting agrees with that of the hardware.

8. Optionally: If the system has more than one E-625, interconnect the E-625s using their Network connectors and an appropriate cable (see Section 5.2 and Section 8.6 on p. 35 for details). Then connect the RS-232 cable from the host computer to each E-625 in turn and configure it. Do not forget to save the configuration with the WPA 100 command. When all E-625s are configured, connect the host computer to the E-625 that is to serve as master. See the E-816 User Manual for details.

9. Check the analog-side, open-loop, zero-point offset of each axis. If it is incorrect, adjust

[2] This requires opening the case.

the ZERO potentiometer as described on p. 23. It assures that the sensor reports 0 when the position is 0. This value is load-dependent and can drift even on a precalibrated system.

10. Check the analog-side, open-loop sensor range calibration. If it is off, adjust it as described on p. 24. It assures that the sensor submodule output is 10 V when the PZT is physically at nominal expansion[3].

11. Check the servo-control (closed-loop) range adjustment. If it is off, adjust it[3]. It assures that when the nominal-range position is commanded (in analog mode, +10 V with servo ON), the PZT is given the output voltage it requires to bring the sensor output to 10 V.

12. Check and adjust the servo-control dynamic behavior[3]. See the E-802 servo-control submodule User Manual for details. The settings explained there include the P and I values for the servo-control loop and the notch filter setting to eliminate mechanical resonance.

13. If hardware adjustments have been made, check and adjust the digital sensor offset and gain parameters (Osen and Ksen) accordingly (See the E-816 Computer Interface and Command Interpreter User Manual for details).

5.2 Networking

For a networked installation, the following conditions must be met:

- Networked units must have the I^{2}C networking lines connected to each E-625 in parallel (Network connector pins 3 & 4 and at least one of the ground lines). The network bus lines are limited to a maximum length of 1 m and a maximum capacitance of 300pF. These lines carry commands and responses.

- If the network includes more than one E-625.CR, one must be set to “sensor master” and the rest to “sensor slave” and the E-625.CRs must have their synchronization lines (pins 7 and 8) bused together (pins

[3] This requires opening the case.

7 and 8 of LVDT and SGS E-625s may be included or not).

A cable with convenient piggy-back D9 connectors is available as E-625.CN for networking of up to four E-625s (see p. 35).

6 Operation

6.1 Setting Operating Mode

Make sure all switches (on front panel) and jumpers (on the main board in the case) are properly set for the operating mode you require (see Operating Modes, p. 12). The command set for computer-controlled operation is explained in the User Manual for the E-816 computer interface and command interpreter submodule.

Over the system lifetime you should occasionally check the calibration values. The zero-point should be checked most often. Less frequently, you should check the other calibration adjustments. Recalibration will be required if system components are replaced or changes in loading are made.

6.2 User Electronics and Sensor Monitor Signal

If you are connecting your own electronics to the sensor monitor signal, make sure it has sufficient input capacitance to eliminate high-frequency interference.

It may be necessary to add a 4.7 nF (ceramic NP0 or COC type) to the input connector. Use shielded cable if possible, otherwise make sure the lead pair is tightly twisted.

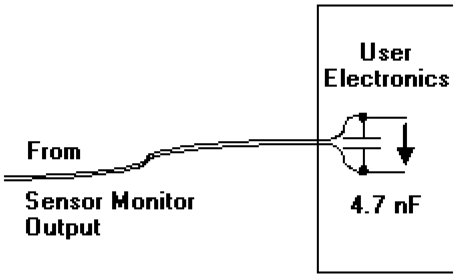


Fig. 1: Electronics on Sensor Monitor line with required input capacitance

7 Settings, Adjustment and Calibration

The procedures mentioned in the Installation Section above are described here in detail. Do not adjust potentiometers unnecessarily, and be aware that many adjustment points are interdependent and effect both computer-controlled and analog operating modes. Reference to the block diagram (p. 30) can aid in understanding the scope of the various control elements.

7.1 Opening the Case

DANGER

Procedures which require opening the case should be carried out by authorized, qualified personnel only.

Disconnect unit from power when opening the case, and when resetting internal switches or jumpers.

When the unit must be operated with the case open, voltages of up to 120 V can be exposed. Do not touch internal conductors.

Only the DIP switch block S1 and the Zero potentiometer are accessible without opening the case. To access other adjustment elements, it is necessary to remove the top cover.

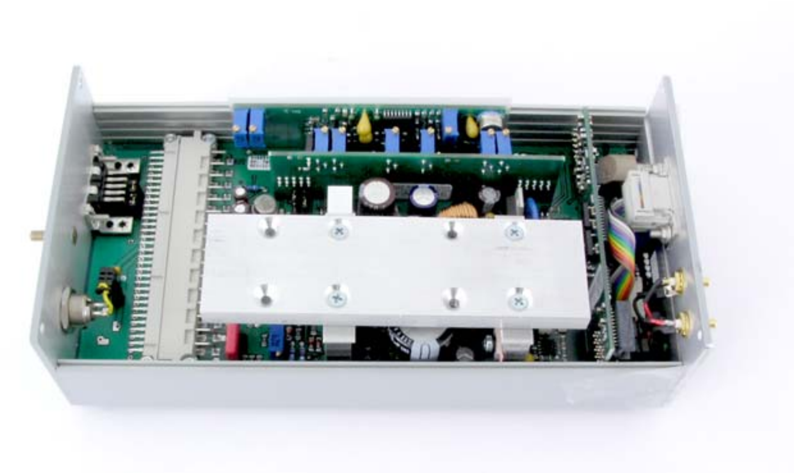


Fig. 2: E-625 with cover off

7.2 E-625 Switch and Jumper Settings

Check the switch and jumper settings carefully: the resulting improper operation may not be immediately evident.

7.2.1 Computer-Controlled vs. Analog Operation

Choose between computer control and analog operation. Analog operation is called for by some calibration procedures, otherwise most users will always be using computer-controlled operation.

	Computer Control	Analog Operation
DIP block S1, switch sw1* (analog input line as target)	OFF	ON
DIP block S1, switch sw2* (computer control target)	ON	OFF
DIP block S1, switch sw3* (servo-control signal)	OFF	see Sect. 7.2.2 & 8.1
DIP block S1, switch sw4* (analog line as wave trigger)	ON	OFF
Jumper J1 (servo bypass off)	2-3**	2-3**

*S1 is accessible through the front panel under "settings"; sw 1 is at the left, and the ON position is down.
** J1 in 2-3 is the default position, and there is almost never any reason to change it. If J1 is in position 1-2, then servo-control, notch filter and slew-rate limiting will all be off, no matter how anything else is set or commanded. See the block diagram on p. 30.

For details of computer-controlled operation, follow the instructions in the *E-816 Computer Interface and Command Interpreter User Manual.*

7.2.2 Servo Mode Selection

The servo-control loop, notch filter and slew-rate limitation is all implemented on the E-802 submodule. If jumper J1 is in position 1-2 the E-802 is completely bypassed no matter what the other settings.

With J1 in position 2-3 the E-802 is connected. Servo mode can then be controlled in a number of different ways.

Servo mode can be switched ON in *either* of two ways:

- By computer command (only if computer-controlled operation is enabled, sw2 ON).

- By setting DIP switch 3 (on block S1, accessible on the front panel under “settings”, 3rd from the left) to ON (down)

Servo mode is OFF if *none* of the above items have it switched ON. With the E-802.55 version of the servo-controller, slew-rate limitation and notch filtering remain on even when servo mode is switched off at the card, but not if the card is bypassed by having jumper J1 in position 1-2.

7.3 Sensor Connection and Adjustment

NOTE

If you inform PI about your application, your E-625s will be fully calibrated before being shipped. It is usually not necessary for you to do anything more than adjust the zero point before operating the system.

CAUTION

!

Calibration should only be done after consultation with PI, otherwise the internal configuration data may be destroyed by erroneous operation.

Position sensors are connected to the sensor input lines (front panel connector, see the wiring diagrams on p. 42). Depending on the E-625 model you have, the submodule for either DC or AC sensor excitation is installed:

- The E-625.LR provides AC sensor processing: it is equipped with the E-801.2x submodule and is primarily for LVDT sensors.
- The E-625.SR provides DC sensor processing (it is equipped with the 801.1x submodule) and is for SGS sensors.

The output from the sensor-processing submodule is an analog signal that is directly proportional to the piezo's expansion and is available at Sensor Monitor on the front panel. See the “E-801 Sensor Processing Submodule” section, starting on p. 34 for more details on the sensor submodules.

As seen in the block diagrams, the sensor signal goes through the sensor readout electronics and then branches to the computer-interface submodule and the servo-control submodule. There are offset (zero-point) and range adjustment potentiometers on the analog side (on the sensor submodule) as well as digital offset and range corrections on the computer interface submodule.

Since the servo-control and computer interface submodules see “copies” of the sensor signal, it is important that the zero point and gain on the sensor submodule be properly adjusted. The zero point is especially likely to need correction.

The A/D converter on the computer interface submodule is always precalibrated and its offset and gain values stored in EPROM: they are not customer modifyable.

If the hardware adjustments are exact, then the Osen (sensor offset) digital correction factor should be set to 0 and Ksen, the sensor coefficient, should be set to a value equal to the travel range (in µm) divided by 10 volts (the nominal sensor submodule output range).

7.3.1 Analog-Side Open-Loop Zero-Point Adjustment

Analog, zero-point calibration has the goal of making the point of zero sensor readout coincide with the point of zero commanded voltage or position. If the electrical zero point is adjusted properly, the full output voltage range of the amplifier can be used and only a small offset is required to get a zero reading. This prevents overflow conditions from occurring.

There might be some small deviation of the electrical zero-point caused by thermal drift or changes in mechanical loading. Let the system warm up for several minutes before setting the zero point.

This procedure can be carried out either in computer-controlled or in analog mode. If you use analog mode, you will need a voltmeter. In computer-controlled mode the voltmeter is helpful but not required. Before starting, install the positioner(s) with the same loads and in the same positions as they will have in your application.

OPEN-LOOP SENSOR ZERO POINT	Computer-Controlled Mode	Analog Mode
1. Set switches on the front panel for operating mode	sw1 OFF, sw2 ON, sw4 ON, connect RS-232 cable to this controller	sw1 ON, sw2 OFF, sw4 OFF
2. Set up for servo-off operation	sw3 OFF	sw3 OFF
3. Connect	Connect directly to host PC with RS-232 cable and power up	Power up
4. Exercise the PZT over the nominal expansion range	Command voltages from 0 to 100 V	Apply analog signals 0-10 V to the analog input[4]. Then set the PZT to 0 by applying 0 V to the analog input[4].
5. Command 0 V	Note the setting of the Osen (sensor offset) parameter (SPA? A8 *n*) and set it to 0 (SPA A8 *n*) Command a voltage of 0 volts (SVA A0)	Put 0 V (= analog ground) on analog input[4]
6. Read sensor	POS?, or read the value at the sensor monitor line with a voltmeter (SMB output on front panel)	Read the value at the sensor monitor line with a voltmeter (SMB output on front panel)
7. Correct zero	Correct the zero setting with the ZERO potentiometer on the front panel.	
8. Save Osen	When the zero setting has been corrected, the Osen value of 0 must be saved to EEPROM (SPA A8 *n*, WPA 100) to assure proper digital operation after the next power up.	

7.3.2 Analog-Side, Open-Loop Sensor Range Adjustment

The object of analog-side, open-loop sensor range calibration is to assure that when the PZT is at nominal expansion the sensor will report the nominal-expansion position. (Note that the voltage required to cause the PZT to expand to its nominal value will not be exactly 100 V, but somewhere in the 85-105 V range.)

All piezo positioning systems ordered together with a PZT translator are delivered with performance test documents to verify the system performance.

[4] Analog input is the SMB socket on the front panel.

The system ordered is calibrated in our labs prior to shipment. Normally there is no need for the customer to perform a full calibration. Only if the PZT, the sensor, extension cable or the mechanical setup is changed, may new calibration be necessary.

Open-loop sensor range adjustment requires an external measuring device with 0.1 µm resolution

DANGER

Procedures which require opening the case should be carried out by authorized, qualified personnel only.

Disconnect unit from power when opening the case, and when resetting internal switches or jumpers.

When the unit must be operated with the case open, voltages of up to 120 V can be exposed. Do not touch internal conductors.

OPEN-LOOP SENSOR RANGE	Computer-Controlled Mode	Analog Mode
1. Make adjustment elements accessible	Open the case (qualified, authorized personal only)	Open the case (qualified, authorized personal only)
2. Set switches on the front panel for operating mode	sw1 OFF, sw2 ON, sw4 ON, connect RS-232 cable to this controller	sw1 ON, sw2 OFF, sw 4 OFF
3. Set up for servo-off operation	sw3 OFF	sw3 OFF
4. Exercise the PZT over the nominal expansion range	Command voltages from 0 to 100 V	Apply analog signals 0-10 V to the analog input. Then set the PZT to 0 by applying 0 V to the analog input.
5. Command 0 V	Note the setting of the Osen (sensor offset) parameter (SPA? A8 *n*) and set it to 0 (SPA A8 *n*) Command a voltage of 0 volts (SVA A0)	Put 0 V (= analog ground) on analog input
6. Check/adjus t zero-point	POS?, or read the value at the sensor monitor line with a voltmeter (SMB output on front panel)	Read the value at the sensor monitor line with a voltmeter (SMB output on front panel)
7. Expand the PZT to its nominal expansion as indicated by external gauge	Use a series of commands like SVA A90 followed by repeated SVR A1	Increase analog input voltage slowly
8. Adjust sensor gain	Adjust the sensor gain on the sensor submodule E-801xx until the sensor monitor output is 10 V. (see E-801 Sensor Processing Submodules, p. 34 for component designation and location.)	
9. Recheck	It may be necessary to repeat the last steps until stable readings are obtained.	
10. Save Osen and Ksen	When the zero setting has been corrected, an Osen value of 0 and a Ksen value of (nominal range)/(10 V) must be saved to EEPROM (SPA A8 *n*, SPA A7 *n*, WPA 100) to assure proper digital operation after the next power up.	

7.3.3 Servo-Control Static Gain Calibration

The object of servo-control static gain adjustment is to assure that the PZT moves to the nominal travel range end position when that position is commanded in servo-on mode (in analog operation, 10 V control input).

You will need an external measurement device

Since the servo-controller uses the sensor signal as a basis, the analog sensor zero point and open-loop range should be adjusted before the static servo-gain is set.

This procedure can be carried out with the unit in either digital or analog mode. If done in analog mode, you will also need a highly accurate voltage source and meter.

DANGER

Procedures which require opening the case should be carried out by authorized, qualified personnel only.

Disconnect unit from power when opening the case, and when resetting internal switches or jumpers.

When the unit must be operated with the case open, voltages of up to 120 V can be exposed. Do not touch internal conductors.

CLOSED-LOOP SERVO STATIC GAIN	Computer-Controlled Mode	Analog Mode
1. Make adjustment elements accessible	Open the case (qualified, authorized personal only)	Open the case (qualified, authorized personal only)
2. Set switches on the front panel for operating mode	sw1 OFF, sw2 ON, sw 4 ON, connect RS-232 cable to this controller	sw1 ON, sw2 OFF, sw4 OFF
3. Set servo ON	Jumper J1 must be in position 2-3 Send SVO A1 command	Set sw3 to ON, J1 must be in position 2-3
4. Check for oscillation	If the PZT goes into oscillation, you will have to perform the dynamic adjustments (especially notch filter) first.	
5. Set external gauge to 0	MOV A0 and set external gauge to 0	Ground analog input and set external gauge to 0.
6. Command a position equal to the end of the nominal travel range	e.g. MOV A100 The PZT should expand to the nominal expansion, and the sensor monitor output* should be exactly 10 V. Verify this with the external gauge and meter	Using an appropriately accurate source apply +10.0000 V to the analog input. The PZT should expand to the nominal expansion, and the sensor monitor output[5] should be exactly 10 V. Verify this with the external gauge and meter
7. Adjust sensor monitor output	To adjust the sensor monitor output[5] to exactly 10.000 V use the GAIN Fine Adjust potentiometer on the servo submodule, E-802.5x	
8. Adjust PZT expansion	To adjust the expansion without changing the sensor monitor output (servo-control is on!) use the gain adjustment potentiometer on the E-801.x sensor module	
9. Repeat the last steps several times until stable results are obtained		

This adjustment can only be done accurately for one type of input (analog input or digital interface input). If you use the unadjusted input, 1% error in the sensor monitor output voltage can be expected.

7.3.4 Servo-Control Dynamic Characteristics

The object of servo-control dynamic calibration is to regulate behavior such as overshoot, ringing and settling time. The servo-control submodule also has a notch filter which makes it possible to eliminate vibration at the mechanical resonant

[5] Sensor monitor output, SMB connector on front panel

frequency of the system.

Dynamic calibration procedures require an oscilloscope (a digital storage oscilloscope is recommended), frequency generator to output square and sine functions from 1Hz to 1 kHz, an ohmmeter with a range from 0.1 to 100 k-ohm.

DANGER

Procedures which require opening the case should be carried out by authorized, qualified personnel only.

Disconnect unit from power when opening the case, and when resetting internal switches or jumpers.

When the unit must be operated with the case open, voltages of up to 120 V can be exposed. Do not touch internal conductors.

The dynamic calibration procedures are described for execution in analog operating mode, though using the wave table it should be possible to perform them in computer-controlled mode. They are described in the User Manual for the E-802 servo-control submodule.
Note that with the E-802.55 version of the servo-control submodule, the notch filter and slew rate limiter are not deactivated by the servo-off line. Resetting the notch filter frequency in this mode (open-loop via servo-off signal) can cause the PZT output voltage to change by as much as 5%. To deactivate the notch filter and slew rate limiter, use jumper J1 in position 1-2 to remove the E-802 from the circuit entirely (see block diagram below).

8 Electronics

8.1 E-625 Block Diagram

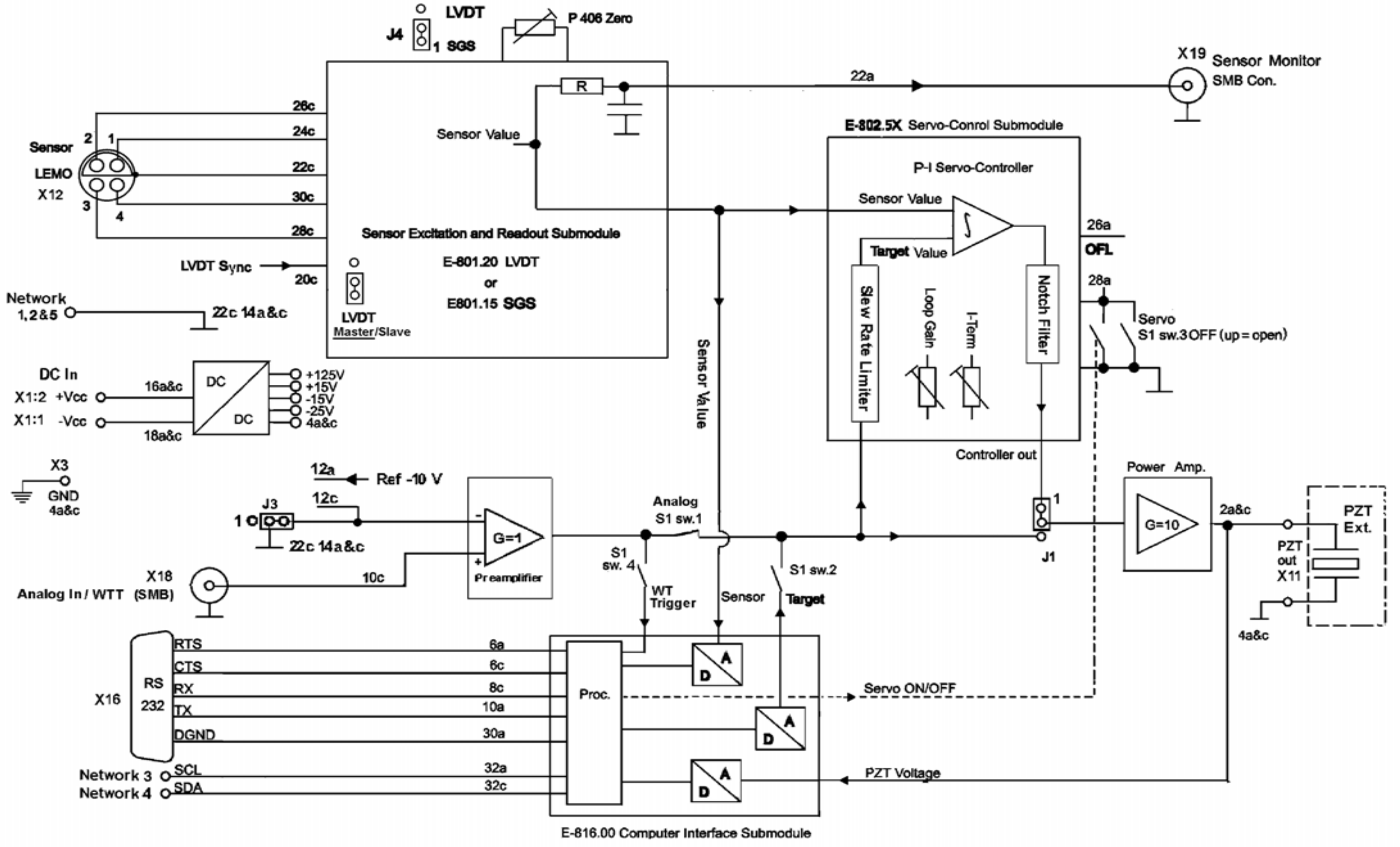


Fig. 3: E-625 Block Diagram

NOTE:
Depending on the switch settings, input signals on the analog input line will be used either as target position or voltage, or as digital input for wave table triggering.

8.2 Components and Adjustment Elements

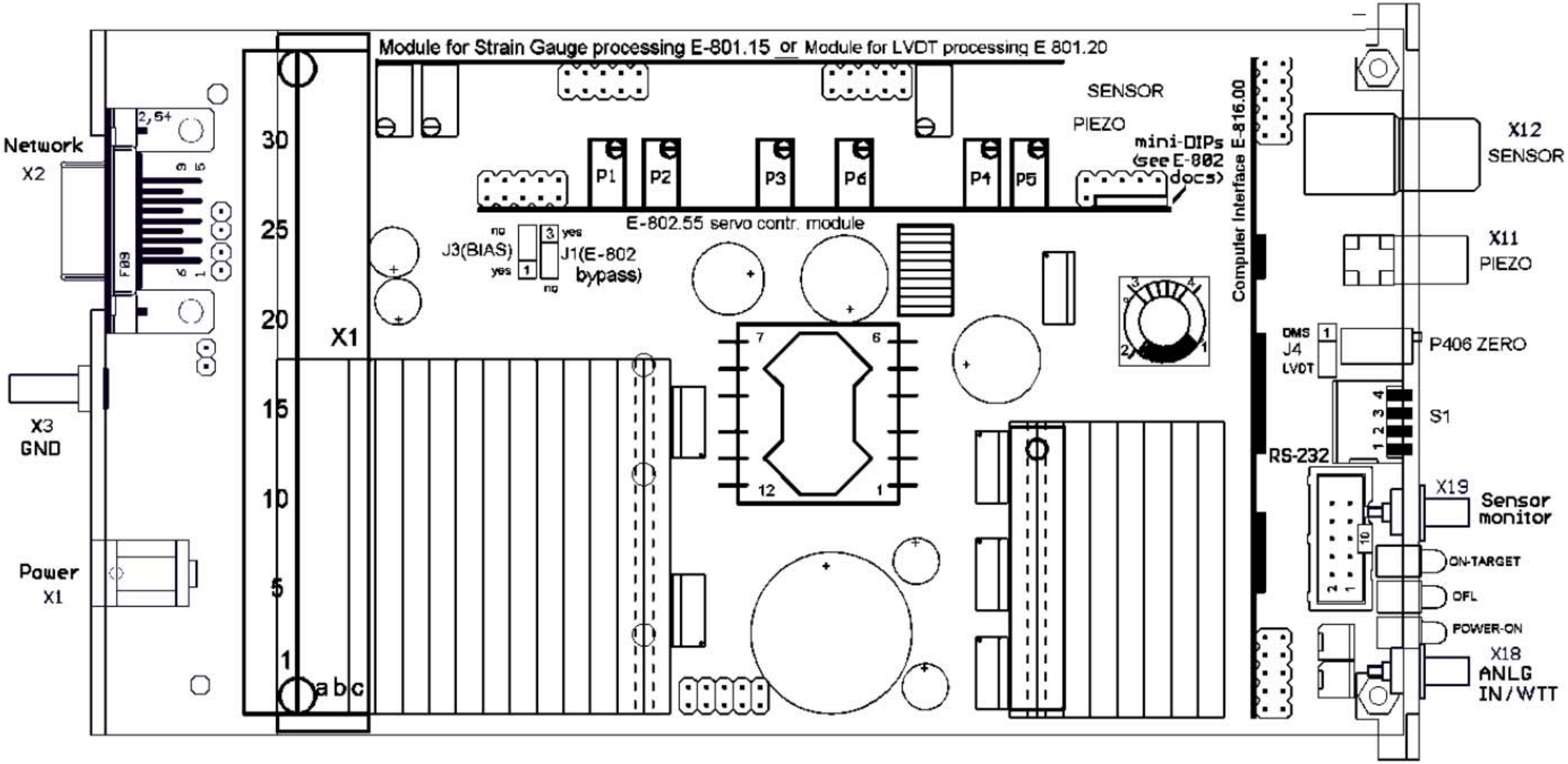


Fig. 4: E-625 (viewed from component side) component locations, see submodule documentation for explanations of items there.

8.2.1 LEDs

Three LEDs are visible on the front panel:

ON TARGET	(green)	Shows state of servo-control module on-target signal
OVERFLOW	(yellow)	PZT output outside of -20 V to 120 V range
POWER ON	(green)	Unit powered up

8.2.2 Jumpers

Most jumpers are also shown on the block diagram on p. 30.

J1 Servo mode, notch filter and slew rate bypass

1-2: E-802 submodule with servo-control, slew rate limitation and notch filter (E-802) is completely bypassed. No other combination of settings or commands can activate it.

2-3: Factory setting: the servo-control mode depends on other settings. With version 802.55, the slew rate limitation and notch filter are always ON, with earlier E-802 versions these functions are only active when servo-control is ON.

J3 Provision for DC offset potentiometer (not included or described):

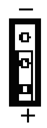
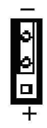
1-2 activated (do not activate without rewiring)
2-3 deactivated

J4 Type of sensor activation/processing:

1-2: DC (strain gauge only),
2-3: AC (primarily LVDT)

Must match the type of sensor-processing submodule installed (E-801.2x for AC, i.e. LVDT sensor; E-801.1x for DC, i.e. SGS sensor)

JP107 - JP109 shift the voltage range of the sensor processing circuitry. They must remain as set at the factory, i.e. for use with an E-802 Servo-Control submodule (positive polarity, 0-10 V)

Position of the Jumper JP107		
Polarity of Output	Positive	Negative

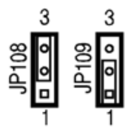
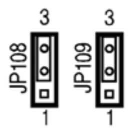
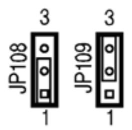
Typical Application	Using with PI's position control electronics	Using as a position detector	Special application
Position of Jumpers JP108 and JP109			
Voltage range of output	0V ~ 10V	-5V ~ +5V	-10V ~ 0V

Fig. 5: E-625 sensor processing output settings

8.2.3 Switches

Switch block S1 is accessible through the front panel.

sw1 (left switch)	ON (down)	Signal on Analog Input line used as analog input
	OFF (up)	Signal on Analog Input line not used as analog input
sw2	ON (down)	Computer interface module target used
	OFF (up)	Computer interface module target not used
sw3	ON (down)	Servo forced on
	OFF (up)	Servo mode depends on other control elements
sw4	ON (down)	Signal on Analog Input line used as wave table trigger
	OFF (up)	Signal on Analog Input line not used as wave table trigger

Unpredictable behavior may result if sw 1, 2 and 4 are set incompatibly. For admissible combinations, see E-625 Switch and Jumper Settings, p. 21.

8.2.4 Potentiometers

The calibration procedures involve setting a number of trim pots. The P406 Zero potentiometer is accessible through a hole in the front panel. Others are located on the main board or on submodules. See also the User Manual of the respective submodule for more details.

8.3 E-801 Sensor Processing Submodule

Sensor excitation and processing is implemented on small, replaceable submodules.

SGS versions have E-801.1x submodules which provide DC sensor excitation and readout. LVDT versions have E-801.2x submodules which provide AC sensor excitation. They can also be connected to SGS sensors if necessary.

On systems with more than 1 networked LVDT version, it is not necessary to synchronize the LVDT excitation frequencies.

Should you ever need to make any adjustments on the sensor submodules, refer to the E-801 User Manual for more details.

8.4 E-802 Position Servo-Control Board

The E-802 is a small plug-in PCB that processes the control signal for the amplifier driving the piezoelectric translators. Slew rate limitation, notch filter and servo-control loop are all implemented on the E-802.

The servo-loop logic compares the control voltage input and the sensor signal to generate the amplifier control signal using an analog proportional-integral (P-I) algorithm.

For calibration procedures, see "Servo-Control Static Gain Calibration", p. 26 and "Servo-Control Dynamic Characteristics", p. 28. The E-802 submodule is described in detail in a separate User Manual.

8.5 Power Supply

E-625s come with a wide-range (100-240 VAC) 15 V wall power supply with a detachable line-power cord and a straight female cord plug (Tiny Q-G® Miniature Connector) matching the power connector in the controller. Replacements can be ordered from PI under E-661.PS

8.6 Network Cable

To network E-625s, a way of busing the required network lines is required. This can be done with E-625.CN cables (not included), which have piggyback sub-D connectors allowing more than one cable to be plugged into a single E-625. Because of length restrictions, at most three such cables can be used.

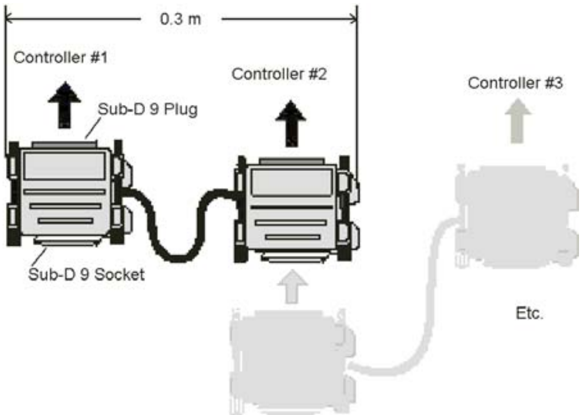


Fig. 6: E-625.CN networking cable

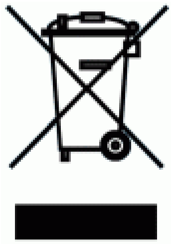
9 Old Equipment Disposal

In accordance with EU directive 2002 / 96 / EC (WEEE), as of 13 August 2005, electrical and electronic equipment may not be disposed of in the member states of the EU mixed with other wastes.

To meet the manufacturer’s product responsibility with regard to this product, Physik Instrumente (PI) GmbH & Co. KG will ensure environmentally correct disposal of old PI equipment that was first put into circulation after 13 August 2005, free of charge.

If you have such old equipment from PI, you can send it to the following address postage-free:

Physik Instrumente (PI) GmbH & Co. KG
Auf der Römerstr. 1
76228 Karlsruhe, Germany



10 Technical Data

10.1 Specifications

Model	E-625.LR	E-625.SR
Channels	1	1
Output voltage range	-20 to +120 V	-20 to +120 V
Peak output current	140 mA (5 ms max.)	140 mA (5 ms max.)
Max. average output current	60 mA	60 mA
Max. average output power	6 W	6 W
Control input voltage range	-2 to 12 V	-2 to 12 V
Voltage gain	10±0.1	10±0.1
Input impedance	> 100 kΩ	> 100 kΩ
Bandwidth	see frequency diagram	see frequency diagram
Ripple of Uout	20 mVpp at low frequencies 40 mVpp (spikes) at 30 kHz	20 mVpp at low frequencies 40 mVpp (spikes) at 30 kHz
Dimensions	205 x 105 x 60 mm	205 x 105 x 60 mm
Weight	1.05 kg	1.05 kg
Operating voltage range	12 to 30 VDC (15 V recommended)*	12 to 30 VDC (15 V recommended)*
Operating current	2 A max.	2 A max.
Sensor type	LVDT, Inductive probes	Strain gauges (SGS)
Sensor excitation†	10 Vpp std, max 25 Vpp, 20 to 20,000 Hz, 50 mA	5 VDC, adjustable
Sensor low-pass filter†	–	selectable 300 Hz, 1 or 3 kHz
Preamplifier gain	selectable 10, 100	–
Sensor monitor	0 to +10 V for nominal expansion	0 to +10 V for nominal expansion
Controller output range	±14.5 V	±14.5 V
Overflow signal*	TTL, active when amplifier output reaches limit	TTL, active when amplifier output reaches limit
Sensor connector	LEMOSA, EPL.0S.304.HLN	LEMOSA, EPL.0S.304.HLN

* The included E-661.PS takes 100-240 VAC, 47-63 Hz and provides 15 VDC
† See E-801 User Manual for latest information

Computer Interface	RS-232, 9-pin sub-D (male)	RS-232, 9-pin sub-D (male)
Sensor monitor	SMB connector	SMB connector
Analog input / wave table trigger connector	SMB	SMB
PZT connector	LEMO ERA.00.250	LEMO ERA.00.250

10.2 Frequency Response Diagram

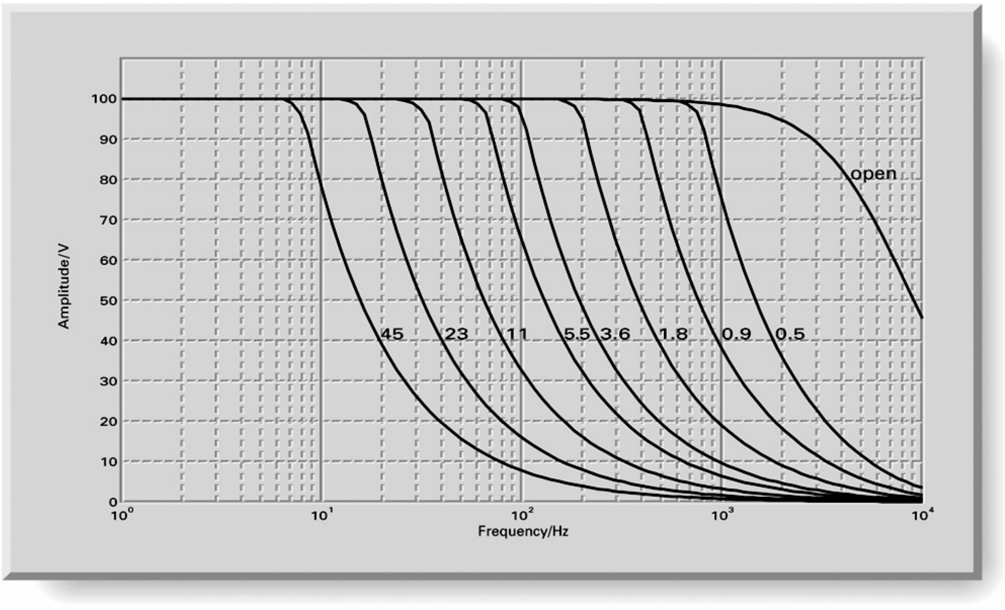


Fig. 7: E-625 open-loop frequency response with various PZT loads. Values shown are capacitance in µF, measured in actual PZT

10.3 Dimensions

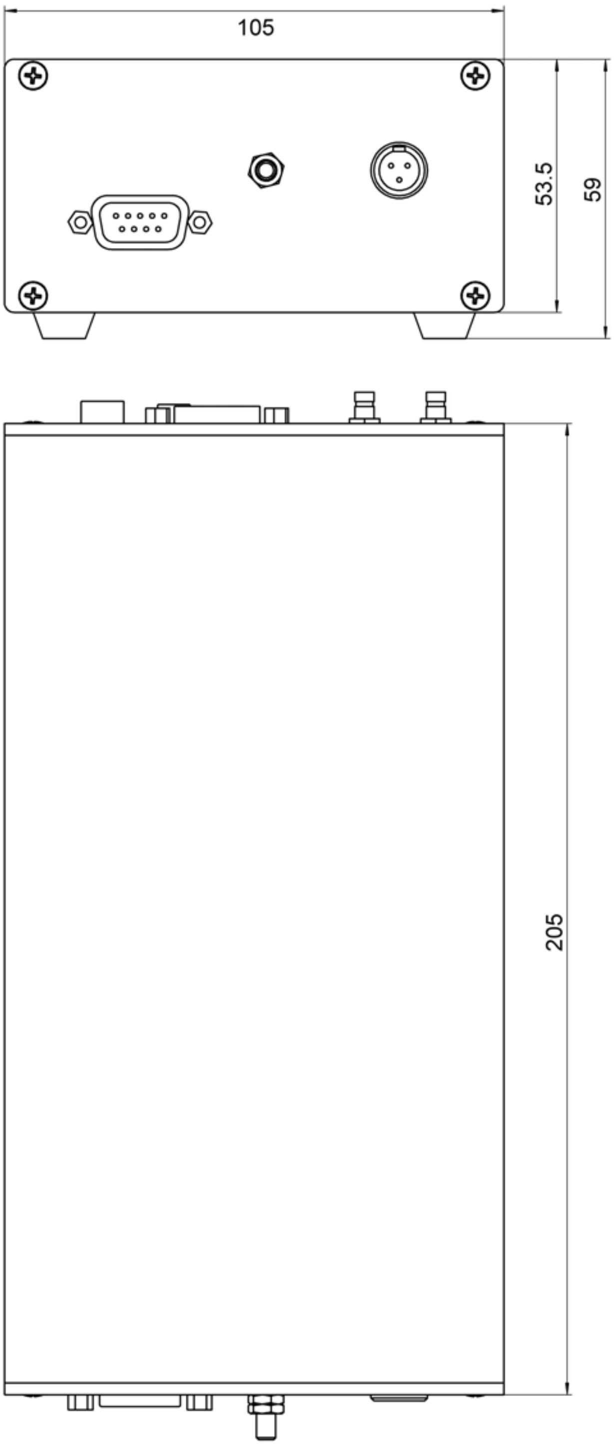


Fig. 8: E-625 dimensions in mm

11 Pin Assignments

Fig. 9: E-625 rear panel

11.1 Network

Sub-D 9 female with the following pinout:

Pin 1, 2 & 5	GND
Pin 3	SCL (I^2C networking)*
Pin 4	SDA (I^2C networking)*
Pin 7	reserved (line used by E-625.CR)
Pin 8	reserved (line used by E-625.CR)
Pin 6 u. 9	n.c.

*The SCL and SDA bus lines are limited to a maximum length of 1 m and a maximum capacitance of 300 pF.

A cable with convenient piggy-back D9 connectors is available as E-625.CN for networking E-625s (see p. 35).

11.2 Power Connector

Pin 1 Power supply GND

Pin 2 12 to 30 VDC (15 V recommended), stabilized

Pin 3 n.c.

Fig. 10: E-625 Power connector, viewed from outside case.

11.3 Ground Stud

Because grounding is not assured over the power connection, the ground stud must be connected to a protective ground. Note that it, the metal case, and the PZT output ground are the same, but are not tied directly to the DC in or logic grounds.

Fig. 11: E-625 front panel

11.4 Analog IN / WTT

SMB coaxial, GND on outer line; depending on switch settings, interpreted either as target position or voltage (-2 to +12 V on inner line), or as wave table trigger signal (TTL).

11.5 Sensor Monitor

SMB coaxial, GND on outer conductor, 0 to 10 V on inner conductor

11.6 Computer Interface

Sub-D 9 male, industry-standard RS-232. See the E-816 Computer Interface Submodule User Manual for interfacing information.

11.7 PZT Connector

2-conductor coaxial LEMO ERA.00.250.
PZT ground is on the outer conductor (tied to case), PZT+ on the inner conductor.

11.8 Sensor Connector

4-conductor LEMO, wiring depends on sensor type.

11.8.1 Strain Gauge Sensor Wiring

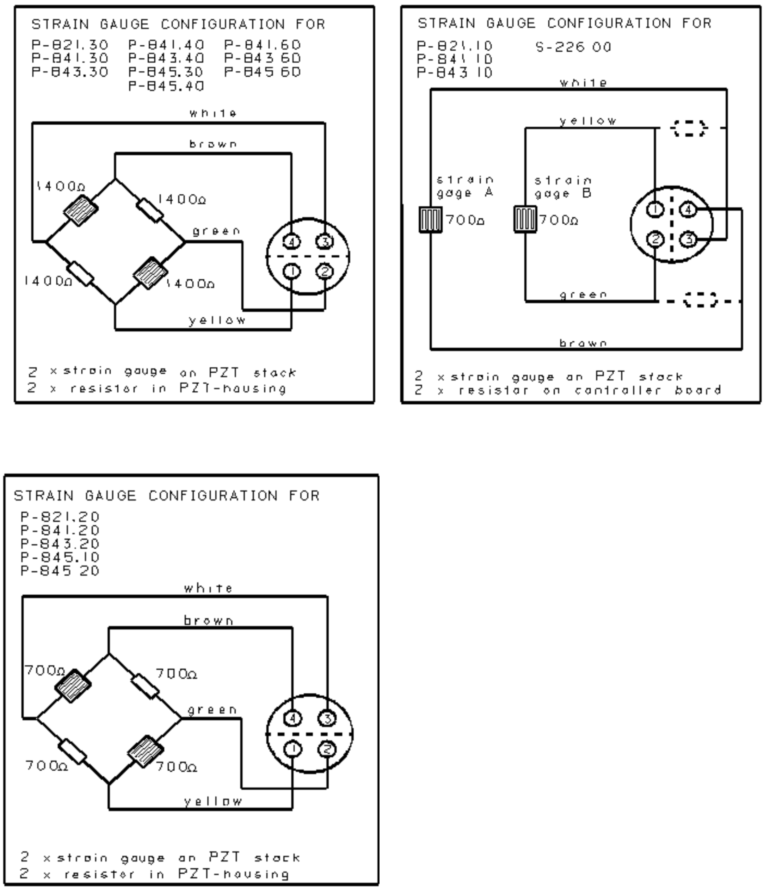


Fig. 12: Pin configurations and wiring for various different stages

11.8.2 Linear Variable Differential Transformer (LVDT) Wiring

Sensors working on the principle of LVDTs usually have a coil with a primary winding, two secondary windings and a moving core. If an AC current is applied to the primary winding, it produces a magnetic field which is concentrated by the soft iron or ferrite core. The magnetic field then passes through the two secondary windings and induces a voltage in each. If the core is moved from the central position, one secondary winding receives more magnetic flux than the other and the induced voltages are different—proportional to the motion. LVDT transducers normally operate at 3 to 5 Vrms, at frequencies between 1 and 20 kHz, and have a typical current consumption between 10 and 50 mA.

The output signal from an LVDT can be expressed as a sensitivity in mV output voltage per volt of supply voltage and per millimeter displacement. Typical LVDT output sensitivity is in the range of about 100 to 250 mV/V•mm, depending on the type.

LVDTs have to be used in conjunction with E-625.LR versions, which are equipped with the E-801.2x AC sensor submodules.

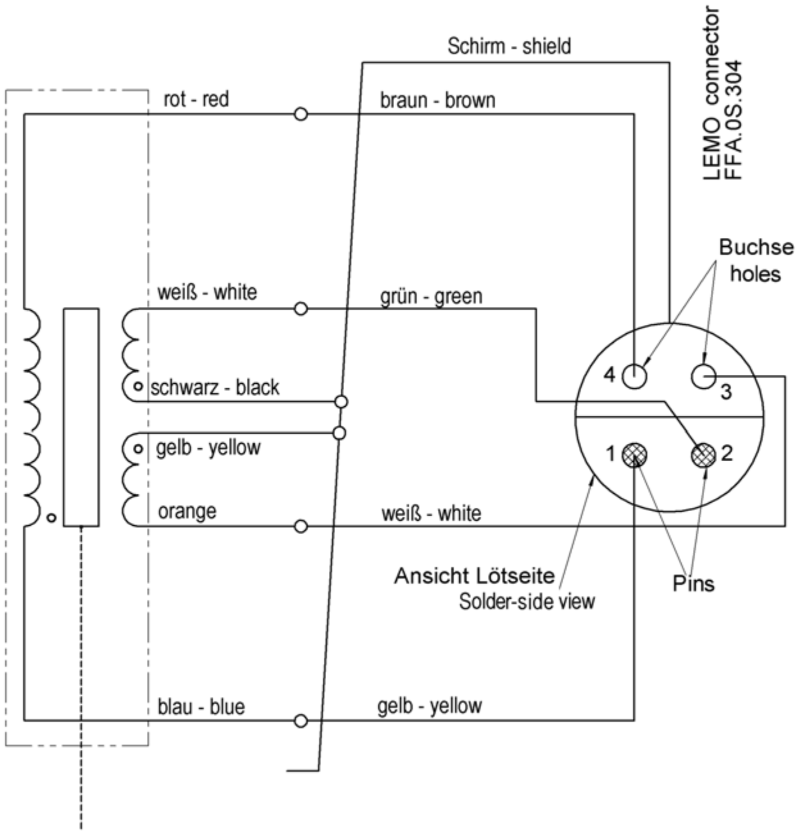


Fig. 13: LVDT wiring diagram

12 Appendix

12.1 Internal 32-Pin Connector

The pinout of this internal connector is provided for informational purposes only.

Pin	Function	Pin	Function
2a	PZT output	**2c**	PZT output
4a	PZT GND (tied to case)	**4c**	PZT GND (tied to case)
6a	RS232/RTS	**6c**	RS-232/CTS
8a	internal use)	**8c**	RS-232/RX
10a	RS232/TX	**10c**	Analog input / wave table trigger input (use depends on sw1 and sw4 settings)
12a	Pot 10 kOhm (-10V)*	**12c**	Pot wiper*
14a	Pot 10 kOhm (GND)*	**14c**	Pot 10 kOhm (GND), also Test GND*
16a	+VCC supply	**16c**	+VCC supply
18a	-VCC supply	**18c**	-VCC supply
20a	Internal use	**20c**	LVDT Sync.In (200KHz)
22a	Monitor sensor	**22c**	GND for Sensor, Test, Analog In
24a	Internal use	**24c**	Sensor excitation
26a	Overflow (TTL, active-low)	**26c**	Sensor inverting input
28a	Servo ON/OFF select	**28c**	Sensor noninverting input
30a	GND for RS232	**30c**	GND for sensor excitation
32a	I^2C SCL-signal**	**32c**	I^2C SDA signal**

* DC-offset pot is not included or described with this product. It is deactivated by jumper J3.

**The SCL and SDA bus lines are limited to a maximum length of 1 m and a maximum capacitance of 300 pF; they appear on the Network connector.