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PZ 160E User Manual

E-621.CR LVPZT Controller/Amplifier

Module

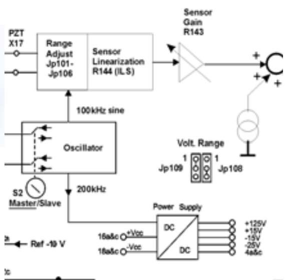
Release: 2.1.0   Date: 2007-06-22

This document describes the following product(s)*:

- E-621.CR
  LVPZT Controller/Amplifier, Single Channel, for Capacitive Sensors

with E-802 servo-control and E-816 computer interface and command interpreter submodules as standard

Strain gauge and LVDT sensor E-621 versions are described in a separate manual, PZ 115E.



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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 Module**
Model Numbers:	**E-621**
Product Options:	**all**

complies—if installed in compatible chassis from PI (E-500.621 or E-501.621)— 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

August 24, 2004
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-621.CR LVPZT Controller/Amplifier Module. 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-621.CR LVPZT Controller/Amplifier Module 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-621.CR LVPZT Controller/Amplifier Modules are described in their own manuals. All documents are available as PDF files 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.

E-802 User Manual, PZ150E
E-816 User Manual, PZ116E
E-816 DLL Software Manual, PZ120E
E816 LabVIEW Software Manual, PZ121E
Analog Controller LabView Driver Library Software Manual, PZ181E
PZTControl Software Manual, PZ146E

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1 Introduction

1.1 Prescribed Use

Based on their design and realization, the E-621.CR LVPZT Controller/Amplifier Modules are intended to drive capacitive loads, in the present case, piezoceramic actuators. The E-621.CR must not be used for applications other than stated in this manual, especially not for driving ohmic (resistive) or inductive loads. E-621.CRs 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-621.CRs 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-621.CRs 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-621 modules are OEM amplifiers generating 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 modules 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 pins 14a and 14c to a Protective Ground!

WARNING

Connect the AC power cord of the system in which the E-621 is installed to the wall socket (85 to 240 VAC).

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

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

CAUTION

Place the system with the E-621(s) 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.

Never cover the ventilation slots as this will impede ventilation.

!

CAUTION

The E-621 main connector pinout is not compatible with the PI EURO board modules of the E-500 series (e.g. E-509 servo-controller or E-50x amplifier).

!

CAUTION

For successful operation of two or more E-621.CRs, their E-500.621 or E-501.621 chassis must have been manufactured after August 2006. Contact PI if you are not sure about the manufacturing date of your chassis.

2 Description

2.1 Hardware

The E-621.CR amplifier/controller is designed as a EURO board plug-in module which can be mounted in a desktop chassis or a 19" rack chassis. In a compatible PI chassis (E-500.621 or E-501.621), networking of E-621.CR’s with each other or with other E-621 models requires no additional wiring.

The E-621.CR comes with an E-802 Servo-Controller and an E-816 Computer Interface and Command Interpreter installed as standard.

The E-500.621 and E-501.621 Basic Module Carriers are based on an EMI-proven chassis with multi-function power supply and a backplane carrying all connectors to the E-621 modules. They are assembled to order, and tested with all your modules installed.

2.2 Functionality

The E-621.CR amplifier/controller module is designed to drive and control the displacement of a low-voltage piezoelectric stage or actuator (LVPZT) in a system with capacitive sensor position feedback. E-621 modules for use with SGS or LVDT sensors are described in a separate manual.

The E-621.CR 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 unit also includes position sensor excitation and readout, servo-control logic, and computer control with multi-axis networking. These last two functions are implemented on small PCB submodules. The submodules are included 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.

Fig. 1: E-621s installed in compatible PI chassis are automatically networked (the LVDT & SGS versions shown here are described in a separate manual)

Basic operation involves the user commanding a motion and the E-621 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 Commanded values are specified by putting a voltage on the Analog Input terminal[2]
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-621 acts like a linear amplifier
Servo ON (closed-loop or position-controlled mode)[3] 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[3] is used to effectuate the move.

Table 1: E-621 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

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[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] Valid input voltage range can be shifted manually using a DC-offset potentiometer, if connected and activated. Operation with the potentiometer alone (input voltage fixed at 0 V) is sometimes called "manual mode".
[3] 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.

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. Note that with the I^2C network lines on the main connector, it is possible to command up to twelve E-621s over a single RS-232 interface from a single host PC. The E-621 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. When the E-621s are installed in a compatible PI chassis (two or more E-621.CRs in a PI chassis require a newer chassis model, recognizable by a "/1" after the serial number), networking is standard without any additional wiring. PI also supplies software to run on the host PC controlling the E-621(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 DIP switch or by shorting main connector pins. 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 capacitive sensors supported by this device are the highest accuracy sensor type available.

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-621 modules 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 amplifier is designed to supply appropriately high peak currents for dynamic applications. Excellent linearity and stability allows the use of E-621 modules in precision measurement and control systems.

Small size and compact design, combined with excellent specifications make the E-621-series controller a preferred module for OEM users.

3 Quick Start

Normally, E-621.CR LVPZT Controller/Amplifier Modules are delivered installed in a compatible PI chassis with a power supply.

1 Connect the chassis to the line voltage. For more information see "Line Power and Fuses" on p. 15.

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 5 below).

3 Connect the piezo stages/actuators to the proper E-621.CR 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 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.

5 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-621 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-621.CR with a computer-generated analog signal (e.g. DAQ board) is treated in this manual as "Analog Control," not "Computer Control."

4.1 Computer-Controlled Operation

Select computer-controlled operation by setting DIP switch 2 (on block S1) to ON (left) and switch 1 to OFF. Make sure jumper X4 is in position 1-2 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

4.2.1 Input Signal

In analog operation, the voltage output to the PZT is controlled by the analog input and an optional 10 kΩ DC-offset potentiometer (not included). The analog input is accepted on main-connector pin 10c provided the S1 DIP switches are properly set. The nominal input voltage range, after addition of up to 10 V of DC offset, 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.

4.2.2 DC Offset

The offset potentiometer, if used, must have the wiper connected to pin 12c and the other two terminals to 12a (-10 V reference) and 14a (GND) respectively. This manual assumes that the clockwise (CW) or high terminal is connected to GND, resulting in increasing output voltage with clockwise motion. In addition, the potentiometer must be enabled by setting jumper X8 (on mainboard) to position 1-2. The potentiometer offsets the nominal input range by up to 10 V. If, for example, you set the output at 50 V for 0 V input with the potentiometer, then the input range will be -5 to +5 V. This feature can thus be used to allow operation from a bipolar input signal.

With the analog input shorted (0 V), the output can be varied from 0 to 100 V with the potentiometer alone. This is sometimes called *manual operation.*

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 X4 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 X4 must be in position 1-2.

- In analog mode, set sw 3 of DIP block S1 to ON or connect pin 28a to pin 14a and 14c (Test GND); note that jumper X4 must be in position 1-2.

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, the yellow Overflow LED lights and an active-low TTL signal (overflow signal) is output on pin 26a

PI's standard calibration procedure assures that the PZT reaches its nominal expansion when that position is commanded (in analog mode with DC offset zero or disabled, 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-621 modules are OEM amplifiers generating 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 modules 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 pin 14a and 14c to a protective ground!

5.1 Line Power and Fuses

The power connection and the line fuses are located on the rear panel of the chassis (E-500.621 or E-501.621). The chassis is equipped with a wide-range power supply and with fuses that are admissible for both 115 V and 230 V operation. No settings need be changed when connecting the system to a different supply voltage. The orientation of the fuse carrier is irrelevant.

WARNING

Before you open the door of the fuse carrier, remove the power plug from the wall socket to disconnect the system from the power supply completely.

!

CAUTION

Both fuses are active and have to be replaced if there is a fault.

To access the line power fuses, proceed as follows:

1 Switch the system off and remove the line cord.

2 Wait one minute to be sure that all electric circuits are discharged completely.

3 Pry open the door that covers the fuse carrier (see Fig. 2) and pry out the fuse carrier.

4 Be sure to replace **both** fuses with:
IEC 4 AT (slow blow)
Note that IEC-standard fuses are designed to carry the nominal current indefinitely. Other fuse rating standards differ.

5 Reinstall the carrier and close the door.

Fig. 2: Fuse location on the rear panel and in the carrier (1 of 2 fuses visible)

5.2 Custom or OEM Chassis

For a custom or OEM installation, the following conditions must be met:

- Networked units must have the I^2C networking lines connected in parallel (E-621 main connector pins 32a and 32c). The network bus lines are limited to a maximum length of 1 m and a maximum capacitance of 300 pF.

- If the network includes more than one capacitive sensor unit, one must be set to “sensor master” and the rest to “sensor slave” and they must have their synchronization lines (E-621.CR main connector pins 20a and 24a) bused together.

- Each unit requires sufficient power. A DC-DC converter is installed on the main board of the E-621 module with an input voltage range of 12 to 30 VDC (recommended supply 15 V). This converter generates -25 and +125 V for the power amplifier and +/-15 V for the sensor and servo-controller. When powering up the module, the DC-DC converter needs a peak current of about 1.5 A to start oscillating. The power supply should have a buffer capacitor, or should be able to supply the 1.5 A per E-621 for at least 1 second. The inputs and outputs of the DC-DC converter are not connected internally. Using a unipolar power supply, we recommend connecting the negative supply at pin 18a and 18c with the Test GND at pin 14a and 14c. This provides a defined GND level and helps to minimize noise.

- Required input and output lines must be connected. Note that many front-panel connections are duplicated on the main connector (see connector pinouts, p. 39).

5.3 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.

1. Set the switches and jumpers on the submodules on the E-621 as required for your application; (for the servo-control and computer interface modules see the respective user manuals).

2. Set the switches and jumpers on the E-621 board as required for your application (see p. 21)

3. If a DC-offset potentiometer is to be used, connect the wiper to pin 12c, the zero-offset contact (presumably CCW) to pin 22c, 14a or 14c (GND) and the other contact (CW) to pin 12a. Make sure the external pot is activated with X8 in position 1-2.

4. Install the E-621(s) in the socket(s). Note that the PI chassis for the E-621 (E-50x.621) is incompatible with other chassis of PI's E-500-series.

5. Connect the positioner(s) and sensors to the E-621(s). In precalibrated multi-axis systems, the serial numbers of the corresponding controller/positioner pairs are marked and must be respected.

6. Power up the E-621(s) and the host computer and start the interface software (e.g. WinTerm).

7. Connect the RS-232 cable from the host computer to each E-621 in turn and configure it. Do not forget to save the configuration with the WPA 100 command. See the E-816 User Manual for details.

8. Connect the host computer to the E-621 that is to serve as communications master using the RS-232 cable. 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. See the E-816 Computer Interface and Command Interpreter User Manual for details and troubleshooting.

9. Check the analog-side, open-loop, zero-point offset of each axis. If it is incorrect, adjust 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 output is 10 V when the PZT is physically at nominal expansion.

11. Check the servo-control (closed-loop) range adjustment. If it is off, adjust it. 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. 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).

6 Operation

6.1 Setting Operating Mode

Make sure all switches and jumpers 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.

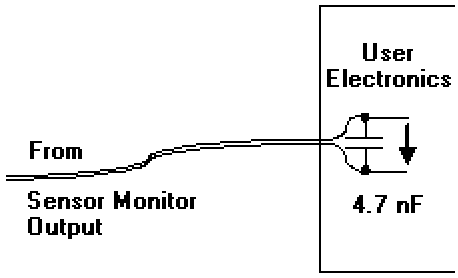


Fig. 3: Electronics on Sensor Monitor line with required input capacitance

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 E-621.CR Switch and Jumper Settings

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

7.1.1 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* (Use Analog In 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. 7.1.2 & 8.1
DIP block S1, switch sw4* (Use Analog In line as wave trigger)	ON	OFF
Jumper X4 (bypass servo)	1-2**	1-2**
Main connector pins 28a and 14 (a or c)	Not shorted	see Sect. 7.1.2 & 8.1

*S1 is accessible through the front panel under “settings”; switch 1 is at the top, and the ON position is on the left.
** If X4 is in position 2-3, 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.*

7.1.2 Servo Mode Selection

The servo-control loop, notch filter and slew-rate limitation is all implemented on the E-802 submodule. If jumper X4 is in position 2-3 this module is completely bypassed no matter what the other settings.

With X4 in position 1-2 the E-802 is connected. Servo mode can then be controlled in a number of different ways.

Servo mode can be switched ON in *any* of three ways:

- By computer command (only if computer-controlled operation is enabled, switch 2 ON).
- By setting DIP switch 3 (on block S1, accessible on the front panel under "settings", 3rd from the top) to ON (left)
- By connecting pin 28a on the main connector to pin 14a or 14c (GND).

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 X4 in position 2-3).

7.2 Sensor Connection and Adjustment

NOTE

If you inform PI about your application, your E-621s 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.

Capacitive position sensors are connected to the front panel connector. If you wire your own connector and interchange Target and Probe lines, the system will still operate but may not attain the specified accuracy.

The output from the sensor-processing circuitry is an analog signal that is directly proportional to the piezo's expansion and is available at Sensor Monitor on the front panel and on pin 22a of the main connector. See the “Sensor Synchronization” section, starting on p. 35 and the Capacitive Sensor User Manual for more details.

As seen in the block diagram (p, 30), the sensor signal goes through the sensor range settings (JP101-JP106), ILS linearization (R144), gain (R143) and zero-adjust (R13), and then branches to the Sensor Monitor output, the computer-interface submodule and the servo-control submodule. The voltage range setting (JP108, JP109) must remain as set at the factory. In addition to the adjustments on the analog side, there are digital offset and range corrections on the computer interface submodule. See the E-816 User Manual for details.

Since the servo-control and computer interface submodules see “copies” of the sensor signal, it is important that the zero point and gain in the sensor circuitry 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 modifiable.

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 module output range).

7.2.1 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 and jumpers for operating mode	sw1 OFF, sw2 ON, sw4 ON; set DC offset = 0 or OFF (X8 2-3); connect RS-232 cable to this module	sw1 ON, sw2 OFF, sw4 OFF
2. Set up for servo-off operation	sw3 OFF, pin 28a not grounded	sw3 OFF, pin 28a not grounded. Set DC offset to 0 or OFF (X8 2-3)
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.
5. Command 0 V	Note the setting of the Osen (sensor offset) parameter (SPA? A8) and set it to 0 (SPA A8 0) Command a voltage of 0 volts (SVA A0)	Put 0 V (= analog ground) on analog input
6. Read sensor	POS?, or read the value at the sensor monitor line with a voltmeter (pin 22a, or the SMB output on front panel)	Read the value at the sensor monitor line with a voltmeter (pin 22a, or the 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, an Osen value of 0 must be saved to EEPROM (SPA A8 0, WPA 100) to assure proper digital operation after the next power up.	

7.2.2 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.)

[4] Analog input is pin 10c or the SMB socket on the front panel.

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

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 and a 32-pin extension connector (P-895.00, not included).

OPEN-LOOP SENSOR RANGE	Computer-Controlled Mode	Analog Mode
1. Set switches and jumpers for operating mode	sw1 OFF, sw2 ON, sw4 ON, set DC offset to 0 or OFF (X8 2-3), connect RS-232 cable to this module	sw1 ON, sw2 OFF, sw 4 OFF
2. Set up for servo-off operation	sw3 OFF, pin 28a not grounded	sw3 OFF, pin 28a not grounded. Set DC offset to 0 or OFF (X8 2-3)
3. 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[5]. Then set the PZT to 0 by applying 0 V to the analog input.
4. Command 0 V	Note the setting of the Osen (sensor offset) parameter (SPA? A8) and set it to 0 (SPA A8 0) Command a voltage of 0 volts (SVA A0)	Put 0 V (= analog ground) on analog input
5. Check/adjust zero-point	POS?, or read the value at the sensor monitor line with a voltmeter (pin 22a, or the SMB output on front panel)	Read the value at the sensor monitor line with a voltmeter (pin 22a, or the SMB output on front panel)
6. 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
7. 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. 35 for component designation and location.)	
8. Recheck	It may be necessary to repeat the last steps until stable readings are obtained.	
9. Save Osen and Ksen	When the zero setting has been corrected, an Osen value of 0 and a Ksen value of *n* (nominal range)/(10 V) must be saved to EEPROM (SPA A8 0, SPA A7 *n*, WPA 100) to assure proper digital operation after the next power up.	

7.2.3 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).

[5] Analog input is pin 10c or the SMB socket on the front panel.

You will need an external measuring device and a 32-pin extension adapter (P-895.00, not included) to access the potentiometers mentioned while the unit is in operation.

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.

CLOSED-LOOP SERVO STATIC GAIN	Computer-Controlled Mode	Analog Mode
1. Set switches and jumpers for operating mode	sw1 OFF, sw2 ON, sw 4 ON, set DC offset to 0 or OFF (X8 2-3), connect RS-232 cable to this module	sw1 ON, sw2 OFF, sw4 OFF; set DC offset to 0 or OFF (X8 2-3)
2. Set servo ON	Jumper X4 must be in position 1-2 Send SVO A1 command	Bridge pins 28a, 14a & 14c on the main connector, or set sw3 to ON, X4 must be in position 1-2.
3. Check for oscillation	If the PZT goes into oscillation, you will have to perform the dynamic adjustments (especially notch filter) first.	
4. Set external gauge to 0	MOV A0 and set external gauge to 0	Ground analog input and set external gauge to 0.
5. 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[6] should be exactly 10 V. Verify this with the external gauge and meter
6. Adjust sensor monitor output	To adjust the sensor monitor output to exactly 10.000 V use the GAIN Fine Adjust potentiometer on the servo submodule, E-802.5x	
7. 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	
8. 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.

[6] Sensor monitor output, pin 22a or SMB connector on front panel

7.2.4 Second Order Polynomial Linearization (ILS)

The capacitive sensor electronics on the main board includes a trim pot (ILS) for minimizing second-order polynomial non-linearity. To adjust the ILS proceed as follows:

1 Before powering up the system, make sure the PZT actuator is mounted in the same way and with the same load as during normal operations in the application. In multi-axis systems, make sure the PZTs are always connected to the same controller modules.

2 Mount an external gauge to measure the PZT displacement. Only if the external measurement system offers higher precision than the capacitive sensor can the maximum performance be achieved. With PZT power amplifier powered down, the external gauge should read 0; if it does not, note the offset and subtract it from subsequent readings.

Caution: Electrostatic Hazard

Electronic components are sensitive to electrostatic electricity. Take appropriate electrostatic protection measures when removing modules.

3 Remove the E-621 from the chassis and reconnect through the extension bracket (not included). To remove the module, proceed as follows:

4 Loosen the two Phillips screws on the front panel.

5 Using the grip at the bottom of the front panel, pull the module out of the chassis.

6 Scan the voltage at CONTROL INPUT from 0 V to +10 V and read the PZT displacement using an external gauge.

7 Adjust the Integrated Linearization System (ILS) by turning the ILS potentiometer (see p. 31) and maximize the linearity of the PZT displacement.

7.2.5 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 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 and, depending on the installation, a 32-pin extension adapter (P-895.00, not included) to allow access to the trim potentiometers while the board is in operation.

The dynamic calibration procedures are described for execution in analog operating mode (sw1 ON, sw2 OFF, sw4 OFF, and DC offset 0 or deactivated by X8 in 2-3), 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 (current production) 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 X4 in position 2-3 to remove the E-802 from the circuit entirely (see block diagram below).

8 Electronics

8.1 E-621.CR Block Diagram

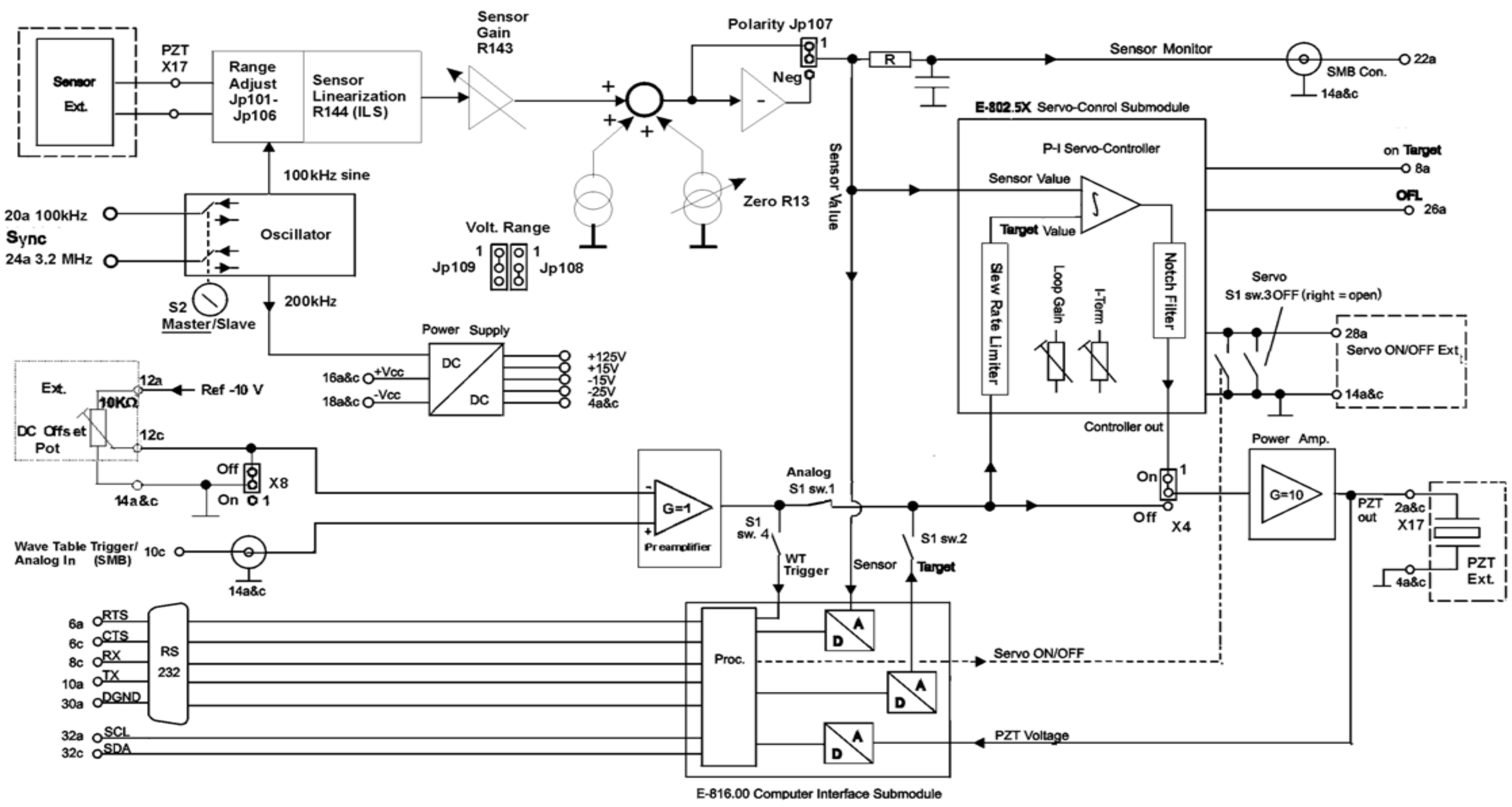


Fig. 4: E-621.CR Block Diagram

NOTE:
Input signals on the analog input line (front panel terminal and main connector pin 10c) and the position of the external DC-offset potentiometer (if activated) are combined in the preamplifier stage. Depending on the switch settings, the resultant signal will be used either as analog input for the power amplifier, as analog input for the position servo-control circuit or as digital input for wave table triggering. If a (TTL) wave trigger is used, DC offset must be deactivated or set to 0.

8.2 Components and Adjustment Elements

See also the E-802 User Manual for adjustment elements on that submodule which are not described here.

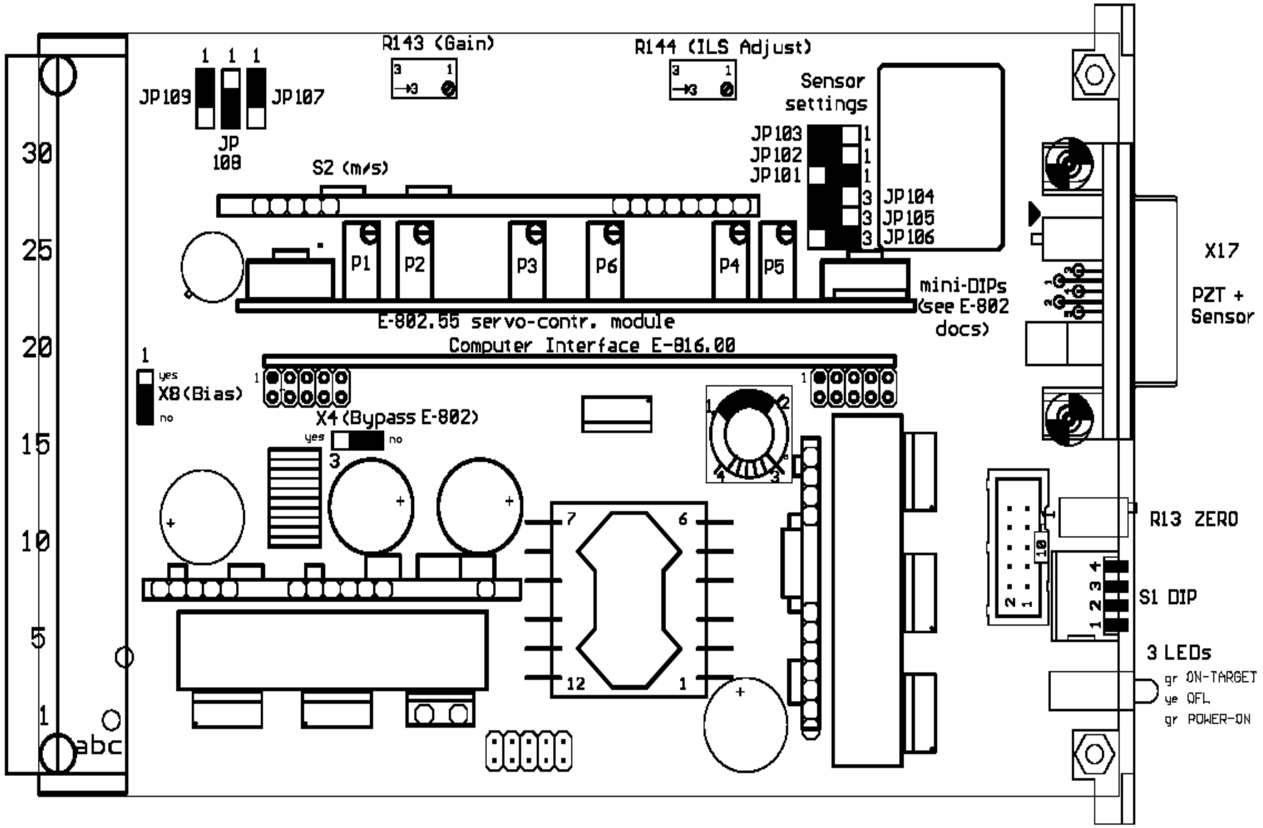


Fig. 5: E-621.CR (viewed from component side, with bottom edge on top) component locations, adjustment elements shown in default settings; all except X4 (E-802 bypass) are accessible without removing cover plate (not shown)

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)	Module powered up

8.2.2 Jumpers

Jumpers are also shown on the block diagram on p. 30.

X4 Servo mode, notch filter and slew rate bypass

1-2: 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.

2-3: 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.

X8 External DC-offset potentiometer:
1-2 activated,
2-3 deactivated

JP101-JP106 Sensor Measurement Range

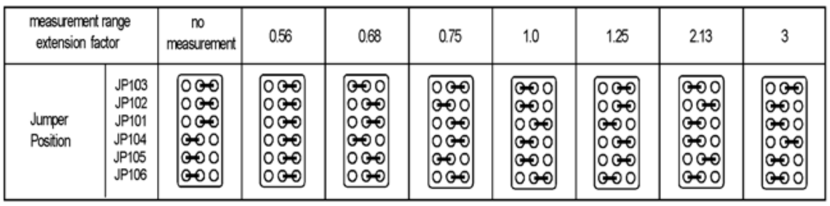


Fig. 6: E-621.CR sensor range jumper settings

The jumper group is shown as arranged on the main board (see component map, p. 31). Units are delivered set as required for

the attached stages. With no information on the stage, PI sets units to 1.0.
JP108 - 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.

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	JP108 3 1 JP109 3 1	JP108 3 1 JP109 3 1	JP108 3 1 JP109 3 1
Voltage range of output	0V ~ 10V	-5V ~ +5V	-10V ~ 0V

Fig. 7: E-621.CR sensor processing output settings

8.2.3 Switches

Switch block S1 is accessible through the front panel. (Do not confuse with the S1 damping control on the E-802 submodule, described in the E-802 User Manual).

sw1 (top switch)	ON (left)	Analog Input line used for analog input
	OFF (right)	Analog Input line not used for analog input (see sw4)
sw2	ON (left)	Computer interface module target used
	OFF (right)	Computer interface module target not used
sw3	ON (left)	Servo-on signal sent to servo submodule
	OFF (right)	Servo-on signal state depends on other control elements
sw4	ON (left)	Analog Input line used for wave table trigger (DC offset must be 0 or OFF!)
	OFF (right)	Analog Input line not used for wave table trigger (see sw 1)

Unpredictable behavior may result if sw 1, 2 and 4 are set incompatibly. For admissible combinations, see E-621.CR Switch and Jumper Settings, p. 21.

Switch S2 (master/slave) for capacitive sensor excitation synchronization (Do not confuse with the S2 mini DIP block on the E-802 submodule, described in the E-802 User Manual). in systems with multiple capacitive sensor units. One system remains as sensor master, the others must be set as slaves (see Fig. 8 for orientation) and the sync. lines of all must be bused together.

Mini-DIP switches on the E-802.55 Servo-Control submodule: see the E-802 manual for description.

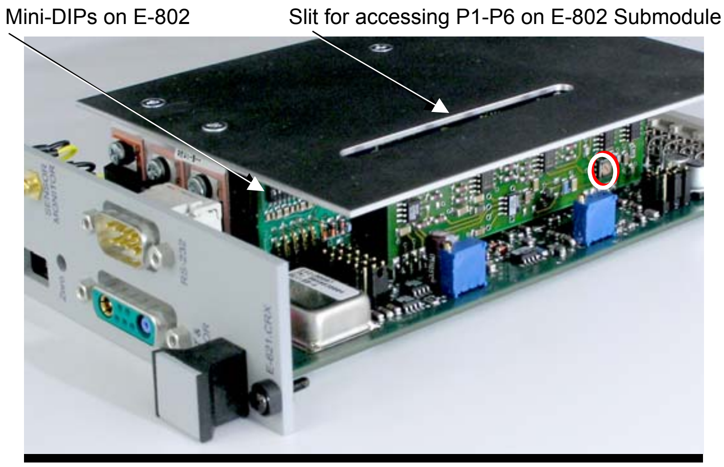


Fig. 8: Master/Slave switch S2 (circled) on PCB soldered perpendicular to main board, shown in default Master position.

8.2.4 Potentiometers

The calibration procedures involve setting a number of trim pots. The R13 Zero potentiometer is accessible through a hole in the front panel. Others are located on the main board or E-802 submodule and require an extension bracket to be accessed during operation.

8.3 Sensor Synchronization

The sensor excitation frequency can be provided internally (S2 master setting) or externally (slave). On systems with multiple E-621.CRs, synchronization is required. Set one unit to master, the rest to slave and make sure all pins 20a and all pins 24a are respectively connected together. This is automatically assured with a newer PI E-50x.621 chassis, recognizeable by a “/1” after the serial number.

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.

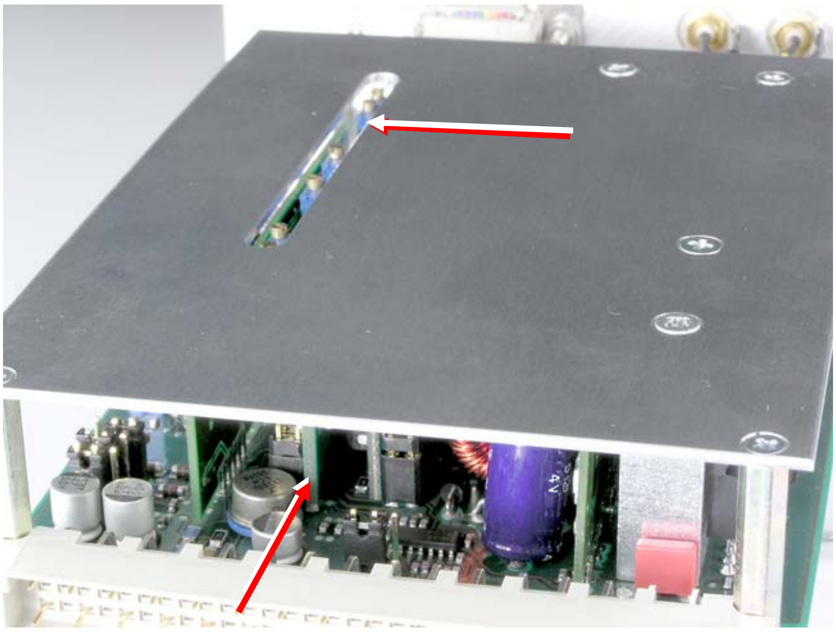


Fig. 9: E-802 servo-control submodule (lower arrow) trim pots accessible through slot (upper arrow) in shield plate

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.

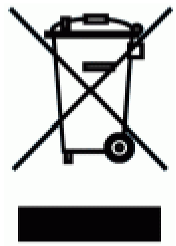
9 Old Equipment Disposal

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

Model	E-621.CR
Channels	1
Output voltage range	-20 to +120 V
Peak output current	140 mA (5 ms max.)
Max. average output current	60 mA
Max. average output power	6 W
Control input voltage range	After addition of DC Offset, must be in -2 to 12 V
Voltage gain	10±0.1
Input impedance	> 100 kΩ
Extern offset potentiometer	adds 0 to 10 V to Control In
Bandwidth	see frequency diagram
Ripple of Uout	20 mVpp at low frequencies, 40 mVpp (spikes) at 30 kHz
Dimensions (Eurocard)	160 x 100 x 35.6 mm
Main connector	32-pin DIN 41612 D
Max. power consumption	22 W
Operating voltage range	12 to 30 VDC, max. ripple 50 mV pp (15 V recommended)
Operating current	2 A max.
Sensor type	Capacitive
Sensor excitation	100 kHz
Sensor monitor	0 to +10 V for nominal expansion
Overflow signal	TTL, active when controller output, < -2 V or > +12 V
Computer interface	RS-232, 9-pin sub-D(male)
Sensor monitor	SMB connector
Analog input / wave table trigger connector	SMB
PZT output and sensor input connector	Sub-D special

Chassis Model	E-500.621	E-501.621
E-621 modules (max.)	12	4
Operating voltage	85 to 240 VAC, 50-60 Hz	85 to 240 VAC, 50-60 Hz
Dimensions	450 x 132 x 296 mm + handles	236 x 132 x 296 mm + handles

11 Pin Assignments

11.1 32-Pin Main Connector

Because the DIN 41612 connector standard includes types with more pins, the 32 pins of the “D” version all carry even number designations and are in rows “a” and “c”.

Pin	Function	Pin	Function
2a	PZT output	**2c**	PZT output
4a	PZT GND	**4c**	PZT GND
6a	RS-232/RTS	**6c**	RS-232/CTS
8a	On-Target (TTL, active low)***	**8c**	RS-232/RX
10a	RS-232/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	100 kHz in/out*	**20c**	nc (reserved)
22a	Monitor, sensor	**22c**	nc (reserved)
24a	3.2 MHz in/out*	**24c**	nc (reserved)
26a	Overflow (TTL, active-low)	**26c**	nc (reserved)
28a	Servo ON/OFF select	**28c**	nc (reserved)
30a	GND for RS-232	**30c**	nc (reserved)
32a	I^2C SCL-signal*	**32c**	I^2C SDA signal*

* Sync lines are output if S2 set to Master, input if S2 set to Slave. The respective sync. lines of the (single) master and the slaves are tied together in newer E-50x.621 chassis, recognizeable by a “/1” after the serial number.
** Pins 14a and 14c should be connected to a protective ground
*** On target signal from E-802 submodule, indicates distance from target less than ±0.19% of range, TTL active-low

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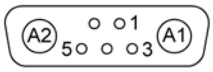
* If E-621s are networked outside a single E-50x.621 chassis, the SCL and SDA bus lines are limited to a maximum length of 1 m and a maximum capacitance of 300pF.

11.2 PZT and Sensor Connector

Special sub-D PZT and sensor connector (X17)



A1 PZT out
A2 Sensor probe
1 DOW (ID-chip download)
2 AGND target and ID GND
3 PZT GND
4 +15 V out
5 Sensor target