Piezo · Nano · Positioning

PZ127E User Manual

E-665 LVPZT Controller / Amplifier

Release: 1.3.0 Date: 2007-06-22

This document describes the following product(s):

- E-665.SR
  LVPZT Controller, Single-Channel, for Strain Gauge Sensor
- E-665.LR
  LVPZT Controller , Single-Channel, for LVDT Sensor
- E-665.CR
  LVPZT Controller , Single-Channel, for Capacitive Sensor

All models with E-802 Servo-Control submodule. E-816 Computer Interface Command Interpreter submodule is also standard, except on E-665.C0, which is described in a separate manual, PZ187.

Auf der Römerstr. 1 · 76228 Karlsruhe, Germany
Tel. +49 721 4846-0 · Fax: +49 721 4846-299
info@pi.ws · www.pi.ws

First printing 2007-06-22
Document Number PZ127E, Eco, Release 1.3.0
E-665_User_PZ127E130.doc

Declaration of Conformity

according to ISO / IEC Guide 22 and EN 45014

Manufacturer:	**Physik Instrumente (PI) GmbH & Co. KG**	CE
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-665**
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

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-665 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-665 LVPZT Controller / Amplifier as well as the 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 positioning stages and the software tools which might be delivered with the E-665 LVPZT Controller / Amplifier are described in their own manuals All documents are available as PDF files. 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-801 User Manual, PZ117E
E-802 User Manual, PZ150E
E-816 User Manual, PZ116E
E-816 DLL Software Manual, PZ120E
E-816 LabVIEW Software Manual, PZ121E
Analog Controller LabView Driver Library Software Manual, PZ181E
PZTControl Software Manual, PZ146E

Contents

Contents

1 General Introduction

1.1 Features

The E-665 is a bench-top device for operating low-voltage piezoelectric translators (LVPZTs). All E-665 models have RS-232 and I^2C interfaces for computer control and networking, a power amplifier, sensor excitation and readout circuitry with different filters and a proportional-integral (P-I) servo-controller. The integrated amplifier can output and sink a peak current of 360 mA and an average current of 120 mA over an extended voltage range of -20 to 120 V. The units can be operated in both open-loop and closed-loop modes. Different models are available for use with LVPZTs equipped with strain gauge, LVDT, or capacitive displacement sensors.

The E-665 can be operated manually by front-panel potentiometers, by external analog signals or by computer over a serial RS-232 communications link. Up to 12 E-665s can be controlled off a single RS-232 computer interface. The block diagram on p. 23 answers most questions about how the various elements interact with each other. Commands are compatible with the *PI General Command Set* (see the E-816 User Manual for computer interfacing and command set details).

E-665s 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-665s in precision measurement and control systems.

Although the E-665 was designed to drive PZT positioning elements, it can also be used to drive other systems which require controlled operating voltages.

1.2 Prescribed Use

Based on their design and realization, E-665 LVPZT Amplifier and Position Servo-Controllers are intended to drive capacitive loads, in the present case, piezoceramic actuators. E-665 must not be used for applications other than stated in this manual, especially not for driving ohmic (resistive) or inductive loads. E-

665s can be operated in closed-loop mode using position sensors (LVDT, DMS or capacitive 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.

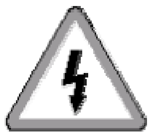
Observe the safety precautions given in this User Manual.

E-665s 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-665s are designed to operate under normal ambient conditions:

- Indoor use only
- Altitude up to 2000 m
- Temperature range 5°C to 40°C
- Max. relative humidity 80% for temperatures up to 31°C, decreasing linearly to 50% relative humidity at 40°C
- Line voltage fluctuations not greater than ±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

1.3 Safety Precautions



DANGER

Read This Before Operation:

E-665s are 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. Never touch any conductive surface that might be connected to the High Voltage circuit.

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.

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

WARNING

Connect the AC power cord of the E-665 to the wall socket (90 to 120 VAC or 220 to 240 VAC).

New line power fuses are required when changing the supply voltage. See p. 38 for more information.

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.

DANGER

Disconnect the E-665 from the power supply completely before opening the case.

CAUTION

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

If you inform PI about your application, your E-665s 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

!

Place the E-665 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.

2 Model Survey

The following models are available to support different position sensor types.

E-665.LR	Equipped with AC sensor excitation and readout circuitry, primarily for LVDT (linear variable differential transformer) sensors, sensor circuitry implemented on the E-801.2x submodule (see the E-801 User Manual for details).
E-665.SR	Equipped with DC sensor excitation and readout circuitry for SGS (strain gauge sensor), sensor circuitry implemented on the E-801.1x submodule (see the E-801 User Manual for details)
E-665.CR	Equipped with capacitive sensor excitation and readout circuitry, implemented on the main board
E-665.C0*	Also for capacitive sensor, but without computer control (basic operation is described in User Manual PZ187)

It is also possible to configure most models so as to accept an externally provided sensor signal of 0-10 V.

The nameplate on the controller rear panel shows the model type, the internal model number (PI-NO; model type plus suffix), the serial number of the device (SN) and information about applicable line voltage and current.

* Some E-665.C0 settings are not applicable and/or are disabled. Technical details can be found here, albeit by inference from E-665.CR only.

3 Principle of Operation

Basic operation involves the user commanding a motion and the E-665 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 or "digital" operation) or a voltage, perhaps computer generated, on the control input line (referred to as analog operation in this manual). If the system is in closed-loop (= servo ON = position-controlled) mode the motion command specifies a target position; if in open-loop (= servo OFF = voltage-controlled) mode, the command specifies a target voltage for the PZT. The various combinations of operating modes are shown in the table below:

Front-Panel Switch Positions *, †	Most-recent servo-mode command†	Computer Interface‡ Commands originating in a host PC	Analog Operation Commanded values are specified by putting a voltage on the Control input terminal and setting DC-offset
Analog Servo OFF	Servo OFF (SV0 *a*0), or none	Motion commands are ineffective or disallowed, other commands work normally.	Input control voltage§ is translated directly into a voltage to be applied to the PZT output. The E-665 acts like a linear amplifier
Analog Servo ON	irrelevant	Motion commands are ineffective or disallowed, servo control not switchable, other commands work normally.	Input voltage§ is interpreted as a target position for the PZT. The servo-control loop* is used to effectuate the move.
Analog Servo switch irrelevant	Servo ON (SV0 *a*1)	Motion commands are ineffective or disallowed, other commands work normally.	Same as above, i.e. servo is ON. Use of servo commands for analog operation can become confusing
Digital Servo OFF	Servo OFF (SV0 *a*0) , or none	Only voltage-setting motion commands allowed, position sensor output is available but is not used internally.	Control input and DC offset are ignored
Digital Servo switch irrelevant, but should be OFF	Servo ON (SV0 *a*1)	Position sensor output is used by the analog servo-control circuitry* to assure that target position is reached. Only position-setting motion commands are allowed	Control input and DC offset are ignored
Digital Servo ON	Servo OFF (SV0 *a*0), or none	Only voltage-setting motion commands allowed, but resulting voltage is interpreted as a position and servo-control is applied. Use of this inconsistent mode is not recommended	Control input and DC offset are ignored

* Servo-control logic is analog (the "digital/analog" switch refers to the way the target is commanded) and implemented on an included plug-in submodule (E-802), described in detail in a separate manual.
† For Servo-control to be OFF, both the command interface and the front panel switch must be set to Servo OFF mode. Note that the servo ON and OFF commands can be run over the computer interface even when the unit is in "Analog" mode.
‡ Computer control and networking functions are implemented on a factory-installed plug-in submodule (E-816) and are described in detail in the separate E-816 manual and in Section 5 (networking). Operating the unit with a computer-generated analog signal is considered under Analog Operation.
§ Valid control input voltage range can be shifted manually using the DC-offset potentiometer. Operation with the potentiometer alone (input voltage fixed, e.g. at 0 V) is sometimes called "manual mode".

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. Note that with the I^2C network connector, it is possible to command up to 12 E-665s over a single RS-232 interface from a single host PC (see Section 4.2 on p. 15 for interface settings). The E-665 connected to the RS-232 link (the master) relays commands to the other units (slaves) on the I2C network. Responses from the slaves are then relayed by the master back to the PC. See Section 5 on p. 20 for details regarding the networking. PI also supplies software to run on the host PC controlling one or more E-665s. (The software is the same as that used with the E-621 and early versions may not mention the E-665). Included are LabView drivers, a COM Server, a DLL Library and the *PZTControl* graphic user interface software. See the associated software manuals for installation and operation details.

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 and a complete command reference.

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 target positions or voltages are “commanded” by putting a *voltage* on the control input terminal and/or adjusting the DC-offset potentiometer. If the unit is in servo-control mode, this voltage+offset will be interpreted as a position (ranging from 0 to the full travel range of the attached actuator). If the unit is in Servo OFF mode, the voltage+offset will be interpreted as a voltage (ranging nominally from 0-100 V) to put on the PZT output terminal.

Using servo-control mode 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 and electronics used. Any one of3 different types of position-control sensors can be used: strain gauge sensors (SGS) attached to the PZT stack, linear variable differential transformers (LVDT), or capacitive sensors.

3.1 Computer-Controlled Operation

In computer-controlled operation, the PZT is controlled by ASCII commands originating in a host PC. Select computer-controlled operation by setting the front-panel toggle switch to "Digital." If this switch is not correctly set, motion commands will have no effect. In "digital" mode the front-panel position and voltage displays are off (position and voltage values are always available over the computer interface). "See the *E-816 Computer Interface and Command Interpreter User Manual* for details and a complete command reference.

3.2 Analog Operation

In analog operation, the voltage output to the PZT is controlled by the voltage on the front-panel Control input and DC-offset potentiometer. 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. To maximize PZT lifetime, keep excursions beyond the standard range to minimum frequency and duration.

The nominal input range may be offset by up to 10 V with the DC-offset potentiometer. 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 control input locked at 0 V, the output can be varied from 0 to 100V with the potentiometer alone. This is sometimes called *manual operation.*

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

To put the unit in open-loop mode—whether in "digital" or analog operation—the front-panel Servo switch must be in the OFF position *and* the computer interface must also be set to Servo OFF (the power-up default).

In open-loop mode (voltage-controlled operation), the position servo-control circuitry (a portion of the E-802.5x submodule circuitry) is deactivated. With the E-802.55 version submodules, the slew rate limitation and notch filter remain active. Adjusting the notch filter potentiometers can cause some shift of the PZT output voltage.

In computer-controlled ("Digital") 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 the DC offset. The sensor electronics works independently of servo mode, and outputs the current piezo position even in open-loop mode, provided a sensor is properly connected.

3.4 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 either use the SVO command or set the front-panel switch to Servo ON. Note that both the Servo ON command and the switch are effective no matter what the position of the Digital/Analog switch (i.e. whether operating in Analog or Computer-Controlled mode!).

In position-controlled mode, the servo-control electronics decide what voltage should be output to the PZT based on the commanded position and the sensor signal. 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 overflow condition is signaled.

PI's standard calibration procedure assures that that the PZT reaches its nominal expansion when that position is commanded (for example, in analog mode with DC offset at 0 and the input control signal at+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 controlled mode, the relationship between target position and PZT supply voltage may not be linear.

4 Starting Operation

Your E-665 is factory-calibrated and ready to use.

The E-665 PZT Controller was calibrated with the PZT translators before shipment. During the calibration process, the expansion of the PZT is checked using an external gauge. Individual characteristics of the amplifier, servo-controller, D/A and A/D converters are accounted for and the corrections made to trim pots or values stored in non-volatile registers.

DANGER

Read This Before Operation:

E-665s are 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. Never touch any conductive surface that might be connected to the High Voltage circuit.

All work done with and on the devices 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.

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

Procedures which require operating the device with the case open require adequate knowledge and training in handling High Voltages and should be carried out by authorized, qualified personnel only.

4.1 Line Voltage Connection

WARNING

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

Unless you request otherwise, upon delivery the E-665 will be set up for the voltage predominant in your country, either 115 VAC or 230 VAC.

To adapt the E-665 to a different line voltage, the line power fuses must be replaced. See p. 38 for instructions and for the required fuse types.

4.2 RS-232 Communication Parameters

The settings of the RS-232 interface used for computer-controlled operation are as follows (see the User Manual for the E-816 plug-in submodule on which the interface is implemented for more detail):

Data rate:	9600 - 115,200 baud (default 115,200)
Data word:	8 bits
Stop bits:	1
Parity:	none
Flow control (required):	RTS/CTS
Termination character for commands:	LF or CR, dec. 10 or 13
Termination character for responses:	LF, decimal 10
RS-232 cable connection: (null modem)	TxD – RxD RxD – TxD RTS – CTS CTS – RTS GND – GND

NOTES

The host computer MUST use a flow-control protocol when communicating with the controller / amplifier.

Strings sent to the device must be terminated by a LineFeed (ASCII 10) or a Carriage Return (ASCII 13).

> Some commands provoke responses (reports). Each report is terminated by a LF (ASCII #10). Reports are never longer than one line.

4.3 Installing the System

If PI had sufficient knowledge of your application and you ordered your system components together, they will be preconfigured. In that case you only need to perform the steps shown in bold below. Steps marked with an asterisk may be skipped if your unit has been properly precalibrated. All operations on the E-665 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-665 from the power supply completely before opening the case. Remove the power plug from the wall socket.

CAUTION

> Place the E-665 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.

1. *Make sure that the E-665 is not connected to line power.

2. *Set the switches and jumpers on the E-665 and its submodules as required for your application; (submodule documentation available as separate User Manuals).

3. *Make sure that the E-801 and E-802 submodules are properly installed on the E-665 (see p. 26).

4 *Set the jumpers on the E-665 board as required for your application (see p. 26).

5 Connect the positioner(s) and sensors to the E-665. In precalibrated multi-axis systems, the serial numbers of the corresponding controller/positioner pairs are marked and must be respected.

6 Connect the E-665 to line power according to the instructions in Section 4.1.

7 Power up the E-665 and the host computer.

8 Connect host computer to the E-665 using the RS-232 cable.

9 Start the interface software (e.g. PZTControl; for RS-232 interface settings see Section 4.2). 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.

10 Optionally: If the system has more than one E-665, proceed as described on p. 20 to establish a network between the devices.

11 Check the analog-side, open-loop, zero-point offset of each axis. If it is incorrect, adjust the ZERO potentiometer as described on p. 31. 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.

12 *Check the analog-side, open-loop sensor range calibration. If it is off, adjust it as described on p. 32. It assures that the sensor output is 10 V when the PZT is physically at nominal expansion.

13 *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.

14 *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.

15 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).

4.4 Operation

Upon power-up, the operation mode is that specified by the front-panel Servo and Digital/Analog switches.

Make sure the front-panel switches are properly set for the operating mode you require. 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, changes in loading are made, or, if you have an E-802.55 submodule, the notch filter frequency changed.

Note that there are separate position monitor range and scale adjustments for the front-panel display and the digital interface (see the block diagram, p. 23).

4.5 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.

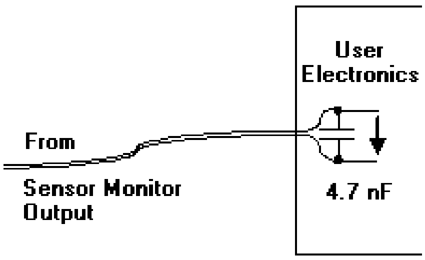


Fig. 1: Electronics on Sensor Monitor line with required input capacitance

5 Networking

Using E-665.CN networking cables, it is possible to command up to 12 E-665s over a single RS-232 interface from a single host PC. The E-665 connected to the RS-232 link (the master) relays commands to the other units (slaves) on this I^2C network. Responses from the slaves are then relayed by the master back to the PC.

DANGER

Disconnect the E-665 from the line voltage before opening the case.

To install the network, proceed as follows:

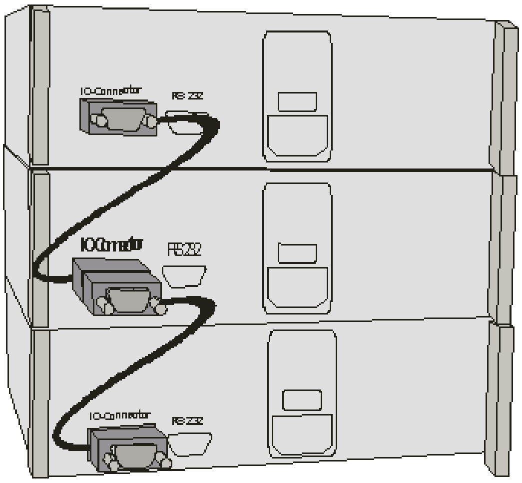
1. **E-665.CR (capacitive sensor version) only—if you have only E-665.SRs and E-665.LRs, skip this step and continue with step 2**.
   Synchronize the clock generation to avoid interference. To do this, determine the synchronization master and slaves using the JP13 jumpers—see Fig. 4 on p. 25 for its location on the board.

   a. Open the cases of all E-665.CR controllers which are to be part of the network (qualified, authorized personal only)

   b. Set JP13 to pin 2 & 3 for the master unit (as shown in Fig. 4) and to pin 1 & 2 for all slave units (not shown).

   Although these settings are in no way concerned with the communication-related master-slave configuration determined by the RS-232 connection, it is recommended that you make the unit which is to be directly connected to the host PC via RS-232 the synchronization master also.

2. Interconnect the E-665s using the E-665.CN networking cables and the I/O connectors on the rear panels as shown in the figure below.



3. Set the channel names for the individual E-665s.
   All devices have the name "A" by default. The master unit—the one which is connected with the host PC via the serial communications cable—is always addressable with the axis designator “A”, but all other units will not be available as slaves as long as they do not have unique names different from "A". To set the channel name for an E-665, proceed as follows:
   - Connect that E-665 to the host PC with the serial communications cable (make it the master unit). Now this device is addressable with the special channel name “A”.
   - Set the terminal software to the same baud rate as the E-665.
   - Use the **SCH** *x* command to assign the desired channel name, *x*, to the E-665. “A” must not be assigned to a unit which will later be accessed as a slave.
   - Use the “`WPA 100`” command to write the setting to the E-665 EEPROM.
   - Reset the device with the `RST` command or with a power off/on reset.
4. Connect the E-665 which is to be the master unit to the host PC via the serial communications cable.

The E-665.CN cable is equipped with piggyback D9 connectors which still allow access to the other signals provided by the I/O connector (for I/O connector pinout see p. 45).

6 E-665 Design

The guiding principle is that the E-816 Computer Interface submodule communicates with the rest of the circuitry using analog signals. This has many implications. For example, servo-parameter setting and sensor calibration is done by adjusting trim pots on the PCBs.

With reference to the block diagram, note the following points:

- Unless otherwise noted, voltage ranges given are the nominal values. Operation to +20% and -20% is supported, but may reduce PZT lifetime
- "Digital" switch position means that the display is off and the servo-control submodule gets its target from the computer interface and ignores the control input and DC offset settings.
- "Analog" switch position means that the display is on and the servo-control submodule gets its target from the control input and DC offset settings. The computer interface is, however, still present in "analog" mode, even though the target it sends is ineffective.
- The front-panel display and the digital interface have separate offset and scaling settings.
- Overflow and On-Target are signals provided by the servo submodule, not calculated in the PC interface.
- Replacing the PZT with one having a different travel range requires resetting both the front panel display and computer interface range settings. The "TARGET" signal, for example, goes from 0-10 V, no matter what the travel range of the PZT.
- Servo-mode is the result of a positive-logic OR operation on signals from the front-panel switch and the computer interface and is independent of the position of the Digital/Analog switch.

For more information on the functions implemented on the servo-control and computer interface submodules, see the respective user manuals. There are also User Manuals for the submodules for SGS and LVDT sensor excitation and readout, as well as one for capacitive sensors.
The E-665 design principle should be evident from the block diagram on the next page.

6.1 E-665 Block Diagrams

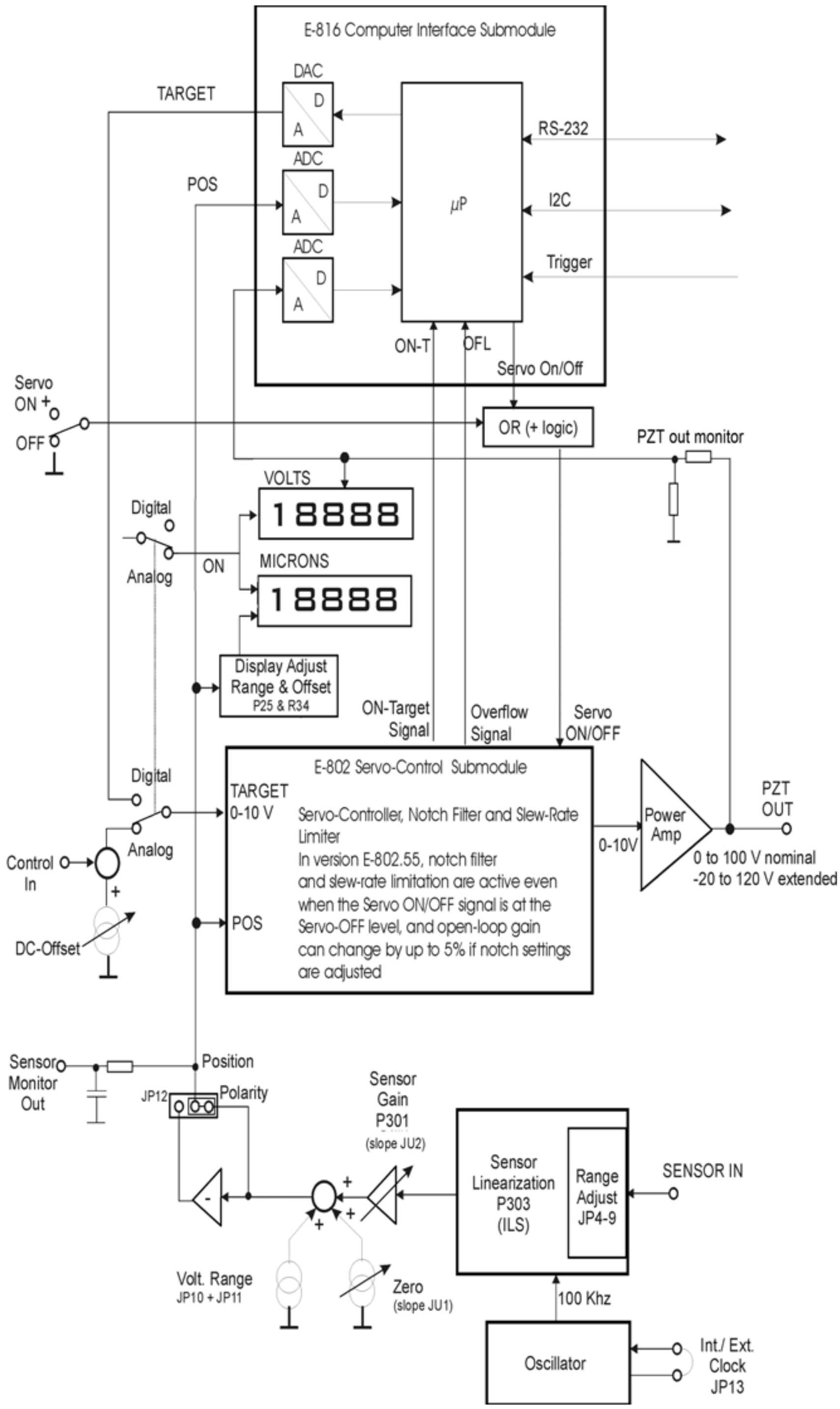


Fig. 2: E-665.CR block diagram

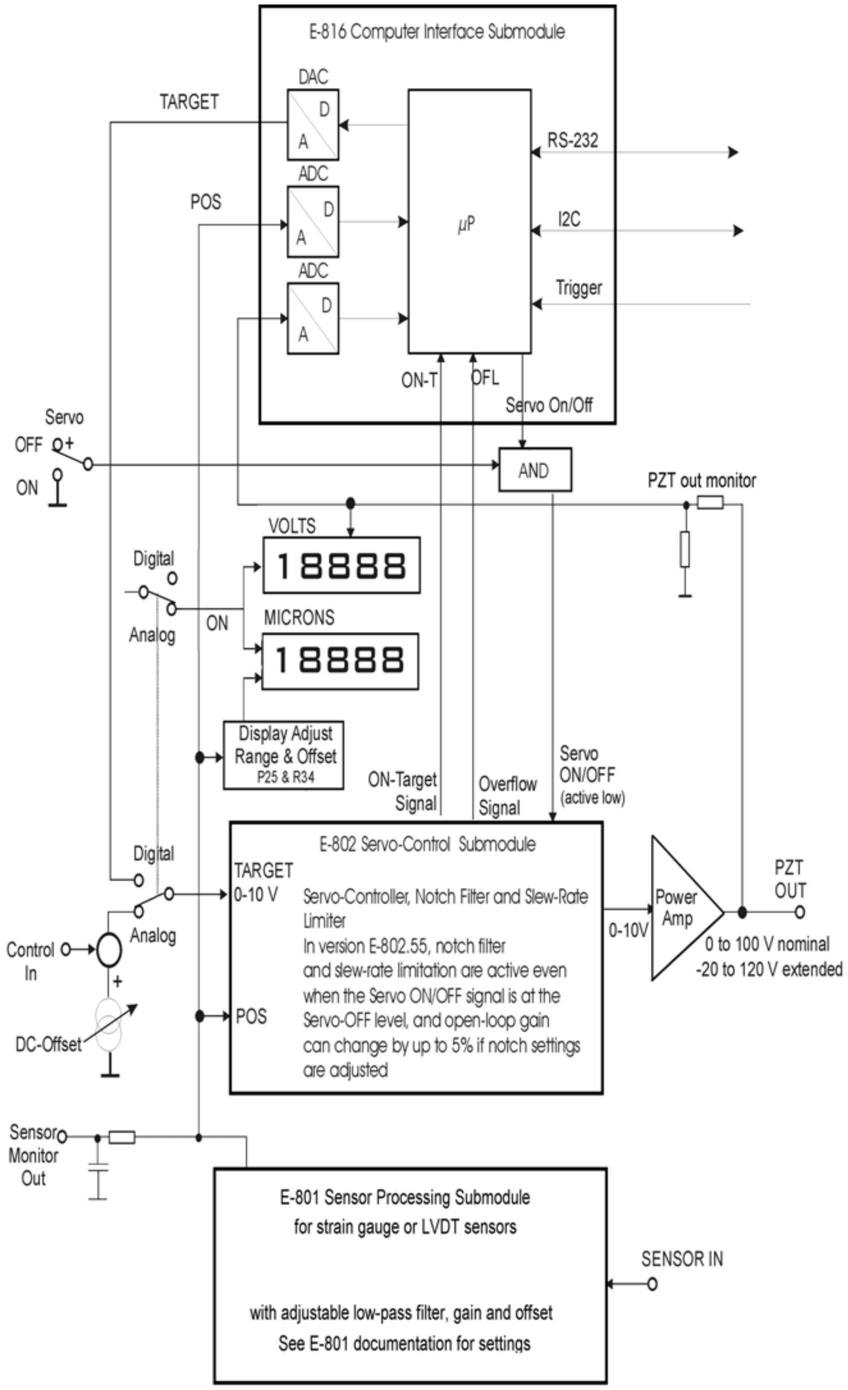
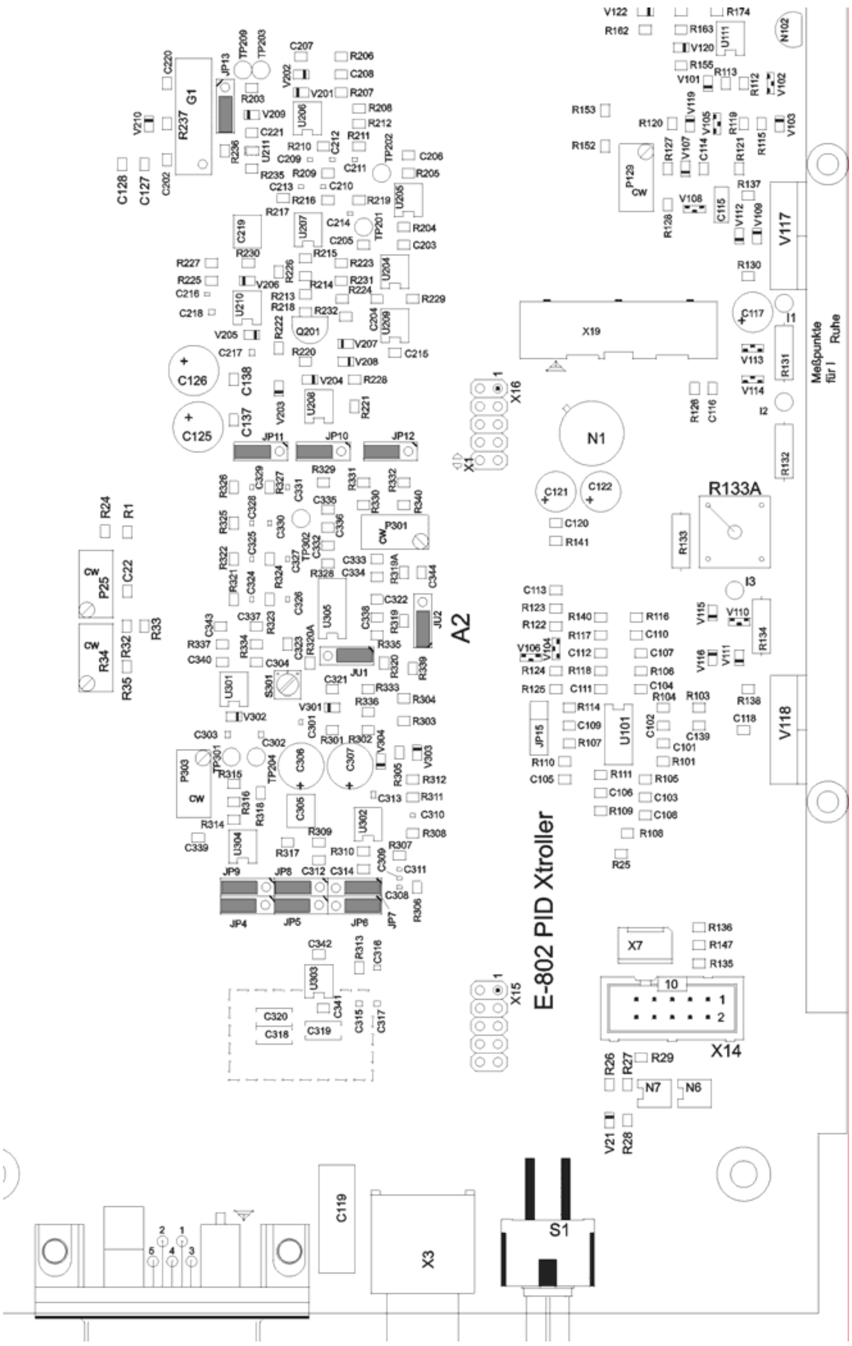


Fig. 3: E-665.SR and E-665.LR block diagram

6.2 Components and Adjustment Elements

6.2.1 Main Board Layout



All jumpers shown in default settings; units ordered as part of complete system may have other settings; defaults subject to change, (e.g. JP 4-9)

Fig. 4: E-665.CR mainboard, partial view, from front-right corner

6.2.2 Submodule Layout

All E-665 models have an E-802 PID servo-control submodule. The SGS and LVDT sensor versions also have an E-801 sensor excitation and readout submodule.

There are a number of different versions of these submodules in circulation, but the basic layout is that shown at right.

For details on the model you have, see the User Manual for the submodule in question.

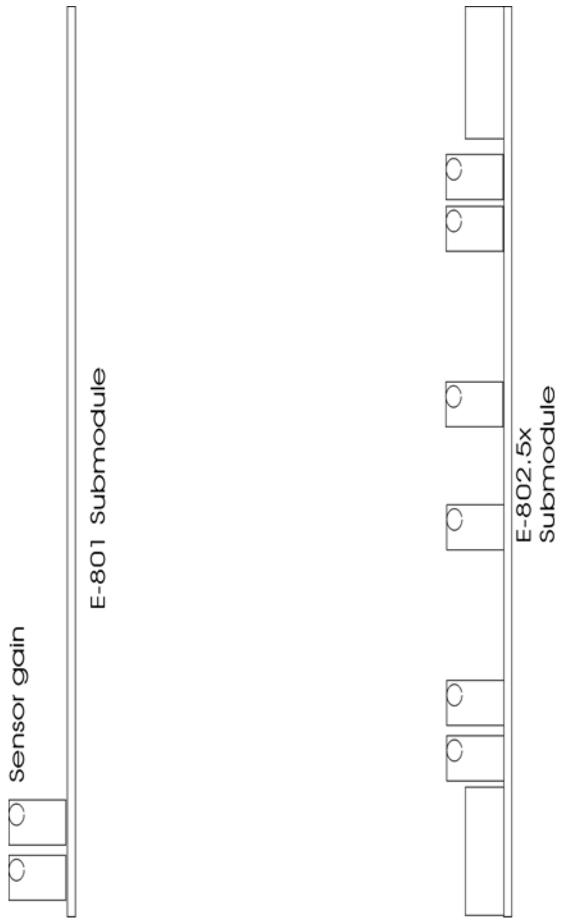
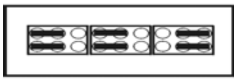


Fig. 5: E-801 & E-802 submodule layout

6.2.3 Jumpers and Adjustment Elements

Default jumper settings are shown in bold, and agree with jumper position shown on block diagram (p. 23). If your unit is part of a complete system with components ordered together, appropriate settings will made before shipping and may differ from the defaults. Some elements are not present on SGS or LVDT models, which have sensor processing implemented on E-801 submodules. See the E-801 User Manual for settings that can be made there.

Function	Designation	Setting
Alternate slope/range selection for zero potentiometer: required for some actuators.	JU1	1-2 standard, e.g. for P-625.1CD 2-3 alternate, e.g. for P-620.1CD
Alternate slope/range selection for sensor gain potentiometer: required for some actuators	JU2	1-2 standard, e.g. for P-625.1CD 2-3 alternate, e.g. for P-620.1CD
Sensor range multiplier (E-665.CR only)	JP 4-9: Factor	JP9 JP8 JP7 top row JP4 JP5 JP6 bottom
	3.0	
NOTE: <u>Some units may be delivered with 2.13 as default sensor range multiplier setting, even when ordered separately.</u>	2.13	
	1.25	
	1.0	
	0.75	
	0.68	
	0.56	
	0.56 without ILS	
Display Adjust Range	P25	trim pot for micron display range
Display Adjust Offset	R34	trim pot for micron display offset
Sensor Bandwidth	S301	
	300 Hz, Low noise	 Center point marked by dot or line
	1000 Hz General use	
	3000 Hz Fast response	
Control input range	JP10 & JP11	both 1-2 for -10 to 0 V both 2-3 for 0 to +10 V

Function	Designation	Setting
Sensor direction	JP12	1-2: pos.: min vol. = min. separation 2-3: neg.: max vol. = min. separation
Clock generation	JP13	3-2: internal clock, use for stand-alone applications 2-1: external, use for multi-axis networked systems
Servo-module bypass	JP15	

7 Settings and Adjustments

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. 23) can aid in understanding the scope of the various control elements. Procedures which involve opening the case are to be carried out by qualified authorized personnel only.

7.1 Servo Mode Selection

The servo-control loop, notch filter and slew-rate limitation is all implemented on the E-802 submodule.

Whether in "digital" or "analog" operation, servo ON (closed-loop) mode can be established in either of two ways:

- By computer command (when the unit is in "analog" mode, all commands except move commands are still effective)
- By switching the front-panel servo switch to the ON position

Servo mode is OFF if *none* of the above items have it switched ON. Note that the computer interface power-up default commands servo mode OFF.

If your E-665 has the E-802.55 version of the servo-controller, slew-rate limitation and notch filtering remain on even when servo mode is switched off. In such devices, you may see a change of up to 5% in open-loop gain when you change the notch filter settings. This is because the notch filter is on and causes the gain to vary by ±5% and in open-loop, this variation is not compensated.

Example: After changing the notch frequency, you apply a voltage of 10 V to the CONTROL INPUT. The voltage at the PZT output may be anywhere in the range of 95 V to 105 V (but with constant value for each notch frequency).

7.2 Sensor Connection and Adjustment

CAUTION

!

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

If you inform PI about your application, your E-665s 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.

Position sensors are connected to the sensor input lines (front panel connector). Depending on the E-665 model you have, either the DC, AC, or capacitive sensor excitation and readout circuitry is installed:

- The E-665.LR provides AC sensor processing: it is equipped with the E-801.2x submodule and is primarily for LVDT sensors.
- The E-665.SR provides DC sensor processing (it is equipped with the 801.1x submodule) and is for SGS sensors.
- The E-665.CR provides sensor processing for capacitive sensors.
- Models with the E-801 submodule (E-665.LR and E-665.SR) can be set up to accept an externally provided sensor signal from 0-10 V. See the E-801 User Manual for details.
- The output from the sensor-readout electronics is an analog signal that is directly proportional to the piezo's displacement and is available at “Sensor Monitor” on the front panel.

As seen in the block diagram, the sensor signal goes through the sensor-readout electronics and then branches to the computer-interface submodule, the servo-control submodule, the position readout display, and the sensor monitor front-panel output. There are offset (zero-point) and range adjustment potentiometers on the analog side (in the sensor-readout circuitry) as well as digital offset and range corrections on the computer interface submodule. The latter are in parallel with yet other range settings for the front-panel display.

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-processing electronics be properly adjusted. The zero point is especially likely to need correction. It is the only setting that can be adjusted without opening the E-665 case, which is to be done by qualified, authorized personnel only.

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 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 with the same load and in the same position as it will have in your application.

OPEN-LOOP SENSOR ZERO POINT		Computer-Controlled Mode	Analog Mode
1	Set operating mode	Digital/Analog switch in "Digital" position	Digital/Analog switch in "Analog" position
2	Set up for servo-off operation	Servo switch in OFF position	Servo switch in OFF position
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 control input. Then set the PZT to 0 by applying 0 V to the control 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 control input*
6	5 Read sensor	POS?, or read the value at the sensor monitor output on the front panel with a voltmeter	Read the value at the sensor monitor output on the front panel with a voltmeter
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 *n*, WPA 100) to assure proper digital operation after the next power up.	

7.4 Analog-Side, Open-Loop Sensor Range (Gain) Adjustment

This adjustment requires opening the case and is for qualified, authorized personnel only.

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

* assuming DC offset is 0 (full counterclockwise); otherwise use the voltages corresponding to the appropriate end of the offset range.

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.

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 sensor gain adjustment accessible	Open the case (qualified, authorized personal only)	Open the case (qualified, authorized personal only)
2. Set operating mode	Digital/Analog switch in "Digital" position	Digital/Analog switch in "Analog" position
3. Set up for servo-off operation	Servo switch in OFF position	Servo switch in OFF position
4. Exercise the PZT over the nominal expansion range	Command voltages from 0 to 100 V	Apply analog signals 0-10 V to the control input. Then set the PZT to 0 by applying 0 V to the control 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 control input[*]
6. 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)

[*] assuming DC offset is 0 (full counterclockwise); otherwise use the voltages corresponding to the appropriate end of the offset range.

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 control input voltage slowly
8. Adjust sensor gain	Adjust the sensor gain until the sensor monitor output is 10 V. (Pot may be on an E-801 sensor submodule, see p.26)	
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.	

7.5 Servo-Control Static Gain Calibration

This adjustment requires opening the case and is for qualified, authorized personnel only.

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.

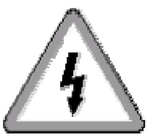
Disconnect unit from power when opening the case, and when resetting internal switches or jumpers.

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 sensor and servo gain adjustments accessible	Open the case (qualified, authorized personal only)	Open the case (qualified, authorized personal only)
2. Set operating mode	Digital/Analog switch in "Digital" position	Digital/Analog switch in "Analog" position
3. Set servo ON	Servo switch in ON position	
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 control 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 (assumed 100), 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 control input*. 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
7. 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 (see E-802 User Manual for details)	
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 submodule (see p. 26)	
9. Repeat the last steps several times until stable results are obtained		

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

7.5.1 Second Order Polynomial Linearization (E-665.CR only)



DANGER

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

---

* assuming DC offset is at 0 (full counterclockwise); otherwise use the voltages corresponding to the appropriate end of the offset range.

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 capacitive sensor electronics 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.
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.
3. Open the E-665 case to obtain access to the ILS trim pot.
4. Scan the voltage at CONTROL INPUT from 0 V to +10 V and read the PZT displacement using an external gauge.
5. Adjust the Integrated Linearization System (ILS) by turning the ILS potentiometer (see p. 25 for its location on the PCB) and observe the linearity of the PZT displacement.

7.6 Servo-Control Dynamic Characteristics

This adjustment requires 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.

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.

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.

8 Maintenance

WARNING

Remove the power plug from the wall socket to disconnect the system from the power supply completely if you want to clean the E-665, open the case or open the door of the fuse carrier.

8.1 Cleaning

The housing surfaces of the E-665 can be cleaned using mild detergents or disinfectant solutions. Organic solvents must not be used.

8.2 AC Power and Line Power Fuses

Unless you request otherwise, the unit will be set up for the power predominant in your country. New line power fuses are required when changing the supply voltage.

CAUTION

Both fuses are active and have to be replaced if the supply voltage changes or if there is a fault.

To access the line power fuses, proceed as follows:

1 Switch the E-665 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. 6) and pry out the fuse carrier.

4 Be sure to replace both fuses with fuses of the type appropriate for the new voltage:

220 VAC to 240 VAC	IEC 0.8 AT (slow blow)
90 VAC to 120 VAC	IEC 1.6 AT (slow blow)

IEC-standard fuses are designed to carry the nominal current indefinitely. Other fuse rating standards differ.

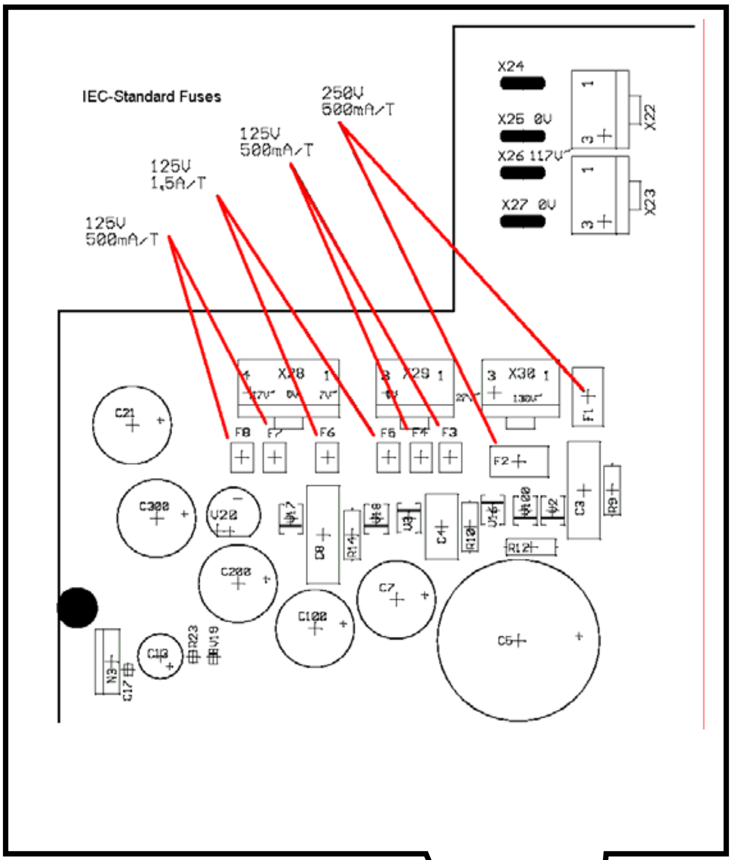
5 Rotate the fuse carrier so that the valid voltage setting (115 V or 230 V) can be seen through the window when the door is closed.

6 Reinstall the carrier and close the door.

Fig. 6: Fuse location on the rear panel and in the carrier (1 of 2 fuses visible)

8.3 Transformer Secondary Winding Fuses

The secondary windings of the transformer on the E-665 board are protected by the fuses F1 to F8. Current ratings given are those for fuses complying with IEC standards. IEC fuses are designed to operate at the nominal current indefinitely. See figure below for the required fuse ratings; all are T-class (slow blow) fuses:



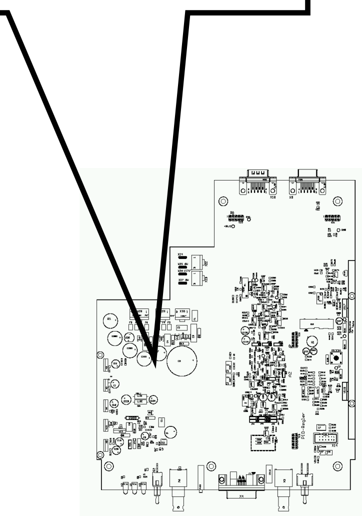


Fig. 7: Fuses for transformer secondary windings on the E-665 board

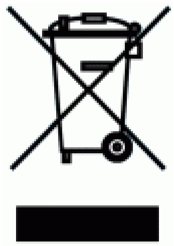
9 Old Equipment Disposal

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-665.SR	E-665.LR	E-665.CR
Distinctive feature	Strain gauge sensor support	LVDT sensor support	Capacitive sensor support
Channels	1	1	1
Amplifier			
Maximum output power	36 W	36 W	36 W
Average output power	12 W	12 W	12 W
Peak output current < 5 ms	360 mA	360 mA	360 mA
Average output current > 5 ms	120 mA	120 mA	120 mA
Current limitation	short-circuit proof	short-circuit proof	short-circuit proof
Voltage gain	10 ± 0.1	10 ± 0.1	10 ± 0.1
Polarity	Positive	Positive	Positive
Control input voltage	-2 to +12 V	-2 to +12 V	-2 to +12 V
Output voltage*	-20 to 120 V	-20 to 120 V	-20 to 120 V
DC offset setting	0 to 100 V with 10-turn pot.	0 to 100 V with 10-turn pot.	0 to 100 V with 10-turn pot.
Input impedance	100 k	100 k	100 k
Display	2 x 4 1/2-digit, LED	2 x 4 1/2-digit, LED	2 x 4 1/2-digit, LED
Control input socket:	BNC	BNC	BNC
PZT voltage output socket	LEMO ERA.00.250.CTL	LEMO ERA.00.250.CTL	Combi sub-D; with sensor lines
Dimensions	235 x 103 x 288 mm	235 x 103 x 288 mm	235 x 103 x 288 mm
Weight	2.5 kg	2.5 kg	2.5 kg
Operating voltage	90–120 / 220–240 VAC, 50–60 Hz (linear P/S)	90–120 / 220–240 VAC, 50–60 Hz (linear P/S)	90–120 / 220–240 VAC, 50–60 Hz (linear P/S)
Interfaces			
D/A Converter	20-bit resolution	20-bit resolution	20-bit resolution
RS-232 baudrate	9.6 kBaud –115.2 kBaud (default 115.2 kBaud)	9.6 kBaud –115.2 kBaud (default 115.2 kBaud)	9.6 kBaud – 115.2 kBaud (default 115.2 kBaud)

* For maximum PZT lifetime, excursions above 100 V and below -10 V should be kept as short and as infrequent as possible.

Wave Table	64 data points, 100 Hz, externally triggered	64 data points, 100 Hz, externally triggered	64 data points, 100 Hz, externally triggered
Position Servo-Control			
Sensor Type	SGS	LVDT	Capacitive
Servo Characteristics	P-I (analog) + notch filter	P-I (analog) + notch filter	P-I (analog) + notch filter
Sensor socket	LEMO ERA.0S.304.CLL	LEMO ERA.0S.304.CLL	Combi sub-D, with PZT lines
Sensor monitor output socket	BNC	BNC	BNC

10.1 Frequency Response

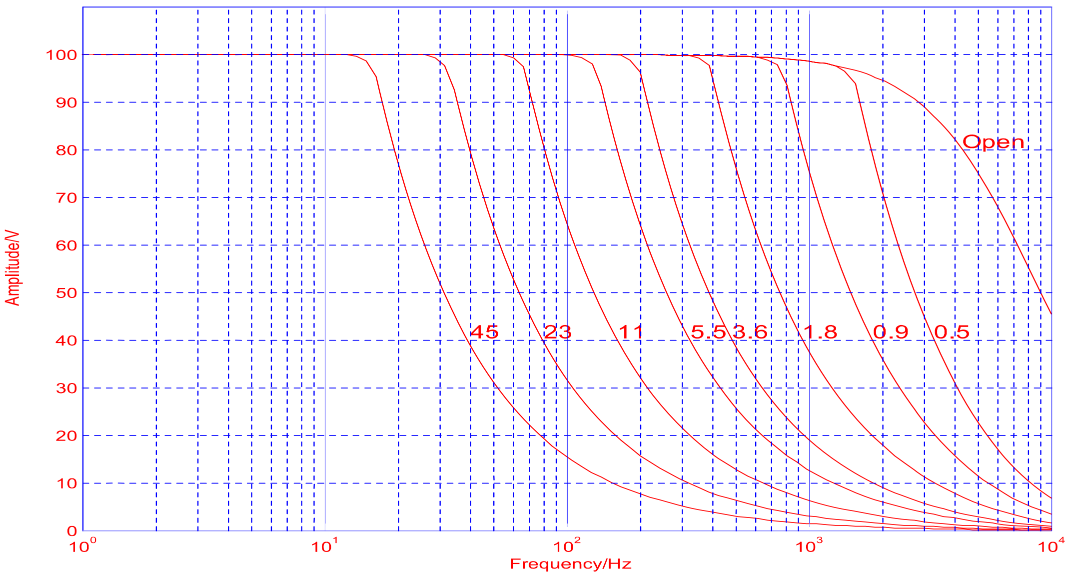


Fig. 8: E-665 open-loop frequency response with various PZT loads. Capacitance values are in µF.

10.2 Front Panel Elements

Fig. 9: E-665.CR front panel

Position and Voltage Displays:
4½ digit, decimal point jumper-settable

LEDs:

ON-T:	on target signal from servo-control submodule (see pin 6, I/O connector (p. 45) and E-802 User Manual for details)
OFL:	overflow signal from servo control submodule (see E-802 manual for details)
S-ON:	servo-control mode

Sensor Monitor:
Filtered and processed sensor output value, 0-10 V.

Sensor Input and PZT Output
On capacitive sensor versions, sensor in and PZT out are together in a combi-sub-D socket

On LVDT and SGS versions sensor and PZT connections are separate.

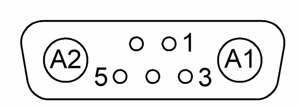


Fig. 10: Sub-D combi socket for PZT and sensor lines in capacitive sensor versions

PZT output voltage range is nominal 0-100 V, extended -20 to 120 V. Excursions out of the nominal range should be infrequent and of short duration to enhance PZT lifetime.

Control In: Analog mode target input signal; nominally range is 10 volts wide, extended range 14 volts wide; range position can be shifted with DC offset control.

Servo ON/OFF switch: when ON, servo mode on; when off, servo mode depends on computer interface.

Digital/Analog switch: Digital for computer-controlled operation, Analog for operation via Control In and DC-Offset

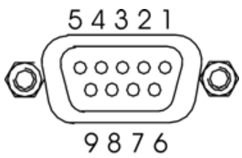
10.3 Rear Panel Elements

Fig. 11: E-665 rear panel with I/O, RS-232, power connectors and fuse compartment

I/O Connector: DB-9f

Pin	Function
1, 2, 5	Ground
3	SCL (for I^2C networking)*
4	SDA (for I^2C networking)
6	On-target output signal (within 0.19% of range), TTL, active-low
7	Sync In (external sensor excitation clock)
8	Sync Out (external sensor excitation clock)
9	Wave table trigger input

Fig. 12: DB-9f I/O Connection



RS 232: DB 9m, Industry standard pinout

* Networking involves connecting SCL to SCL and SDA to SDA of all networked units. Cables with piggyback D9 connectors are ideal for networking and still allow access to the other signals.

11 Position Sensors

11.1 Wiring of Strain Gauge Sensors

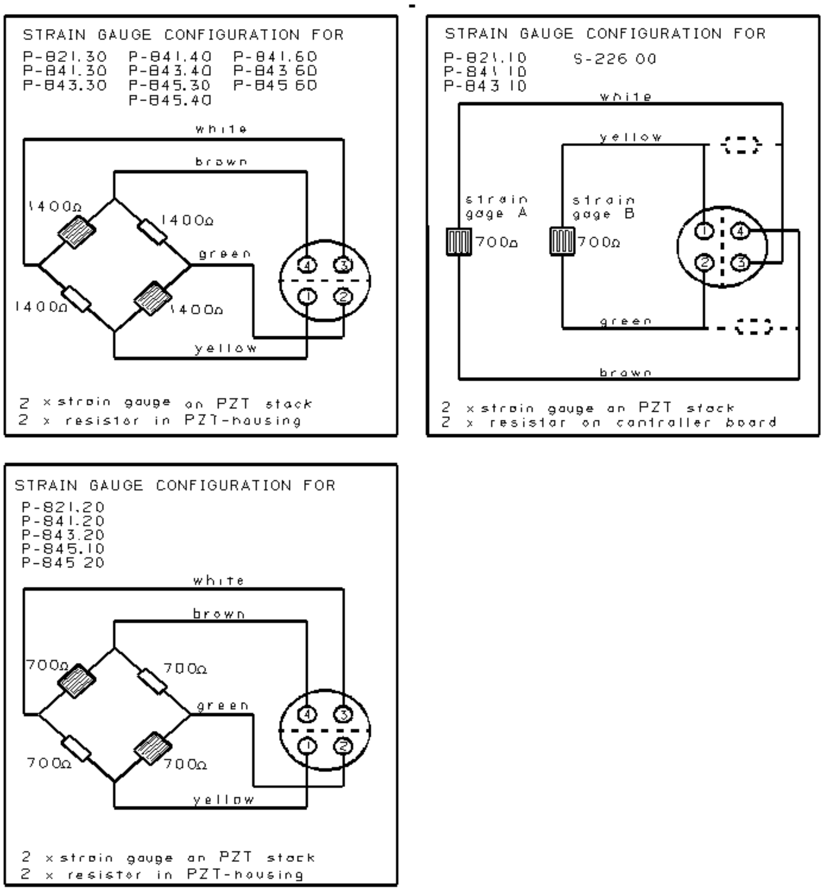


Fig. 13: SGS sensor wiring with various PI stages

11.2 Linear Variable Differential Transformers (LVDT)

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-665.LR versions, which are equipped with the E-801.2x AC sensor submodules.

LVDT Pin Configuration

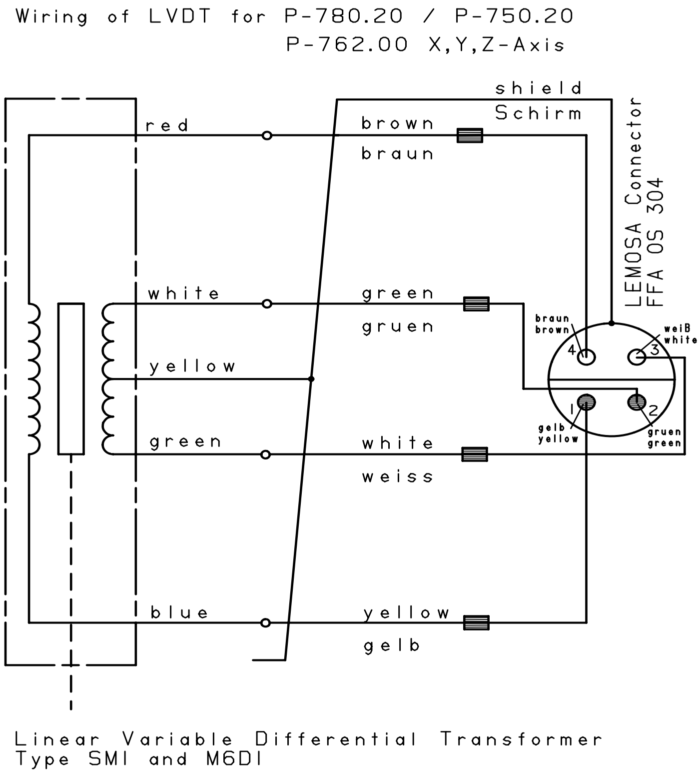


Fig. 14: LVTD sensor wiring

11.3 Two-Plate Capacitive Sensors

The capacitance of a 2-plate capacitor depends on the distance between the plates, called the probe and target plate. Using this principle for high-resolution position detectors requires complex signal processing electronics to match the high accuracy and stability intrinsic to the hardware, but gives the highest resolution possible of any sensor type.

All parts of a capacitive sensor system—both probe and target plates, the signal conditioning electronics and the connecting cables—have to be matched for best results. The unique ILS (Integrated Linearization System) offers high linearity over the full measuring range.

If you are using a PI stage with integrated capacitive sensor, simply plug in the stage as marked. The capacitive sensor lines and PZT output lines are all on a single sub-D-combi connector. Refer to the User Manual of the stage for information on its performance, temperature dependence and frequency response.

In addition, you may need to refer to more detailed documentation on capacitive sensors available from PI.

NOTE

A capacitive sensor consists of a matched pair of one PROBE and one TARGET plates. You should not mix up different probes/targets due to accuracy considerations. If you mix up PROBE and TARGET, the sensor system will work but results may not be as accurate as specified.