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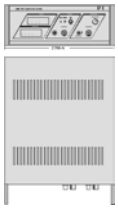
PZ 73E User Manual

E-662 LVPZT Position Servo Controller

Release: 1.4.3 Date: 2004-12-07

This document describes the following product(s):

- **E-662.LR**
  LVPZT Position Servo Controller for LVDTs
- **E-662.SR**
  LVPZT Position Servo Controller for Strain Gauge Sensors



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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
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Karlsruhe,
Germany

The manufacturer hereby declares that the product

Product Name: **LVPZT Position Servo Controller**
Model Numbers: **E-662**
Product Options: **all**

conforms to the following EMC Standards and normative documents:

Electromagnetic Emission: EN 61000-6-3, EN 55011

Electromagnetic Immunity: EN 61000-6-1

Safety (Low Voltage Directive) : EN 61010-1

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About this Document

Users of this Manual

This manual is designed to help the reader to install and operate the E-662 LVPZT Position Servo Controller. 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-662 LVPZT Position Servo Controller as well as the procedures which are required to put the associated motion system into operation.
This document is available as PDF file. Updated releases are available via FTP or 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:

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.

Related Documents

The software tools, which might be delivered with the E-662 LVPZT Position Servo Controller, are described in their own manuals. All documents are available as PDF files on the Motion CD. Updated releases are available via FTP or email: contact your Physik Instrumente sales engineer or write info@pi.ws.

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1 Introduction

This operating manual describes the functionality and the use of E-662 LVPZT Amplifier / Position Servo-Controller. The E-662 is a bench-top device for operating low-voltage piezoelectric translators (LVPZTs) in open-loop and closed-loop (position controlled) mode. The E-662 can be used with LVPZTs equipped with strain gauges or LVDT displacement sensors. The integrated amplifier can output and sink a peak current of 360 mA and an average current of 120 mA.

The E-662 can be operated manually by front panel potentiometers, by external analog signals or by computer over a serial RS-232 communications link. Commands are compatible with the SCPI (Standard Commands for Programmable Instruments) convention and are transferred as ACSII strings.

1.1 Key Features

- 36 Watt Peak Power
- Position Servo-Control
- For Strain Gauges and LVDT Sensors
- RS-232 Interface
- 12-bit D/A converter
- SCPI command set

1.2 Safety Precautions

DANGER

Read This Before Operation:

E-662s 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.

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 involving opening the case should be carried out by qualified, authorized personnel only.

1.3 Model Survey

E-662.LR LVPZT Amplifier/position Servo-Controller, for LVDT sensors, with RS-232 interface

E-662.SR LVPZT Amplifier/position Servo-Controller, for Strain Gauge sensors, with RS-232 interface

Option: External trigger input

2 Front-Panel Elements

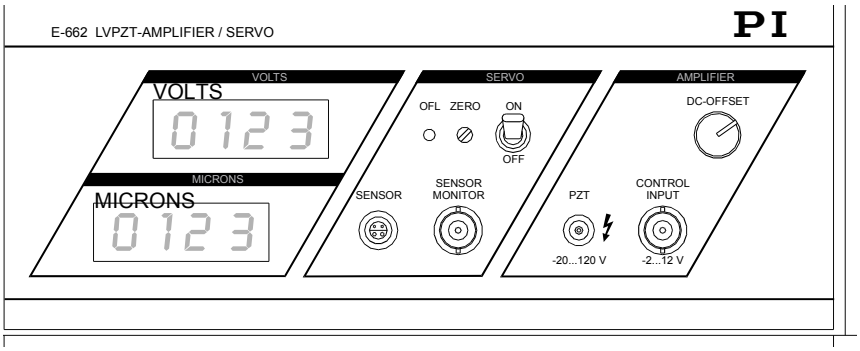

Fig. 1: E-662 LVPZT-Amplifier / Servo

Operating and Display Elements:

VOLTS	LED Display showing current PZT output
MICRONS	LED Display showing current sensor reading
SENSOR	LEMO connector socket for displacement sensor
OFL	Overflow LED
ZERO	Adjustment potentiometer
ON/OFF	Toggle switch for Servo-ON / Servo-OFF
SENSOR MONITOR	BNC socket for sensor monitor output
PZT	LEMO socket for PZT operating voltage (-20 to +120 V)
DC-OFFSET	Potentiometer for manual PZT setting
CONTROL INPUT	Input for external analog PZT control signals (BNC)

3 Quick Start

Your E-662 is factory-calibrated and ready to use.

The E-662 PZT Controller was calibrated with the PZT translators before shipment. During the calibration process, the expansion of the PZT is compared with an external standard. Individual characteristics of the amplifier and servo-controller are accounted for and the correction values for position and voltage are stored in non-volatile registers.

LOCAL mode is active upon power up.

The E-662 can be set to LOCAL or REMOTE-control mode. Upon power up, local mode is active and all front-panel operating elements are activated. The DC-offset potentiometer can be used to set the output voltage. The displays show the current output voltage and displacement.

3.1 Starting Operation

1 With the unit powered down, connect the PZT translator to the PZT socket and the sensor the SENSOR socket.

2 For remote-controlled operation, connect the RS-232 communication port with the PC using a null-modem cable (PI order# C-815.33).

3 Set the servo-switch to OFF and turn the DC-OFFSET potentiometer counterclockwise (CCW) to a hard stop.

4 Connect the line cord. The wide-range power supply allows using the E-662 with any supply voltage from 90 to 240 VAC.

5 Switch the power on.

6 After power on, the device is in local mode and allows manual setting of the PZT by turning the DC-OFFSET potentiometer. Watch the VOLT reading corresponding with the potentiometer setting.

For remote controlled operation, continue with the following steps:

7 Start the WinTerm terminal program on the host computer.

8 Set the communications parameters to: RTS/CTS, 9600 baud, 8 data bits, 1 stop bit, no parity. Choose the host computer COM port to which the RS-232 cable is connected.

9 Check communications. Type "DEV:CONT REM" and terminate the string with ENTER. This command enables remote control over the interface. The blinking decimal point in the VOLTS display indicates the REMOTE control state. The remote state is valid until LOCAL mode is selected with "DEV:CONT LOC". In local mode the decimal point does not blink. Set the device to REMOTE control by "DEV:CONT REM".

10 Now test the voltage output. Type "VOLT 20" to set the PZT output voltage to 20 V. The VOLTS display shows the voltage at the PZT.

4 Operating Modes

The E-662 can be operated in any one of 6 different modes—3 open-loop (voltage controlled, servo-OFF) and 3 closed-loop (position controlled, servo-ON)

4.1 Open-Loop Modes

In the open-loop modes the input to the controller is interpreted as voltage-setting commands and the signal from the position sensor (if any) is not used to refine the position attained.

4.1.1 Manual Operation

The output voltage can be set by a 10-turn DC-offset potentiometer in the range of 0 to 100 V.

4.1.2 External Operation

The output voltage is controlled by an analog signal applied to the BNC input ranging from -2 to +12 V. Multiplying by the gain factor of 10, an analog output voltage range of -20 to +120 V results. The DC-offset potentiometers allow for a continuous variation of the input voltage range between -2 to +12 V and -12 V to +2 V.

4.1.3 Computer-Controlled Operation

The output voltage is controlled via the RS-232 computer interface in the range of 0 to 100 V with a resolution of 12 bits. The DC offset potentiometer, the BNC analog input and the servo-ON/OFF switch are inactive when in computer controlled mode.

4.2 Closed-Loop Modes

In the closed-loop modes the input to the controller is interpreted as position-setting commands and the signal from the position sensor is used to assure that the PZT reaches the position commanded using a servo-control algorithm.

4.2.1 Manual Operation

Displacement of the PZTs can be set by a 10-turn DC-offset potentiometer in the range of zero to nominal displacement.

4.2.2 External Operation

Displacement of the PZT is controlled by an analog signal in the range of 0 to +10 V, applied to the BMC input. The controller is calibrated in that way, the 10 V corresponds with the maximum nominal displacement and 0 V corresponds with 0 displacement. The DC-offset potentiometer can be used to add an offset voltage of 0 to 10 V to the signal input.

4.2.3 Computer Controlled Operation

Displacement of the PZT is controlled via the RS-232 computer interface in the range of 0 to maximum nominal displacement with a resolution of 12 bits. The DC-offset potentiometer, the BNC analog input and the servo-ON/OFF switch are inactive when the E-662 is set to computer controlled mode.

5 Computer-Controlled Operation

In computer-controlled operation, the PZT output is determined by ASCII commands sent to the controller over the RS-232 interface.

5.1 RS-232 Communication

Specifications:

Data rate:	9600 baud
Data word:	8 Bit
Stop bits:	1
Parity:	none
Handshake	RTS/CTS
Termination character for receive:	LF, decimal 10
Termination character for send:	LF, decimal 10
Max. command length:	8 commands in one communication cycle
RS-232 cable:	Null-modem cable
Cable wiring:	TxD...RxD RxD...TxD RTS...CTS CTS...RTS GND...GND

Notes:
One command cycle may include up to 8 commands.
The command execution speed is limited by the baud rate of 9600.
Any string sent to the device must be terminated by a LineFeed (ASCII 10).
Report strings (responses) are also terminated by a LineFeed (ASCII 10).

5.2 Sending Commands

The E-662 command set is based on the SCPI *(Standard Commands for Programmable Instruments)* as described in the "Command Reference" section.

Commanding the PZT can be done in open-loop or closed-loop mode. Any commands using VOLT keyword are commanding voltages in open-loop (no sensor control) and command having

POS keyword are commanding positions using closed-loop servo-control.

Examples:

Commanding output voltages:

VOLT 58.20	output set to 58.2 V (short form command)
or	
SOUR:VOLT 58.20	same result, E-515 compatible

Commanding displacements:

POS 12.5	displacement set to 12.5 µm (short form command)
or	
SOUR:POS 12.5	same result, E-515 compatible

If a command parameter exceeds the allowed range, this command is ignored and error bits of the Event Status Register (ESR) are set. The ESR is reset when the register is read.

5.3 Command Sequence Example

Example #1

SCPI COMMAND	E-662 Response	Function
DEV:CONT REM		Set the E-662 in REMOTE mode (interface controlled), front-panel operating elements are disabled
VOLT 38.5		Sets the E-662 in servo-off mode and output to38.5 V
VOLT?	38.499	Reconverts the voltage output to decimal
POS 12		Sets the E-662 in servo-on mode and expands the PZT to position 12 micrometers.
POS?	12.0	Reports the current position
VOLT:LIM:HIGH 50		Sets the upper limit for VOLT commands to 50 V
VOLT 70		Attempts to set voltage to 70 V. But this is beyond the voltage limit of 50 V. The command is not executed.
VOLT?	38.449	The old voltage has not changed.
VOLT 48.0		Set the voltage to 48 V. This command is accepted because the voltage is within the limits.
VOLT?	48.01	Reads the output voltage
SYST:ERR?	ERROR code and description	Reads the error queue
SOUR:POS 20		Sets the position to 20 µm. The command is given in long form with optional node of the SCPI tree.
VOLT?	48.01	The last voltage setting is still unchanged

6 Calibration Register Structure

One of the key benefits of the E-662 is the calibration register structure. After the device has completed the calibration runs in our lab, absolute positions and voltages can be commanded. The calibration data is stored in non-volatile EEPROM. Write access is protected by a password.

As long as the system configuration has not changed, calibration data are valid and do not need to be changed.

7 Dynamic Operation

The E-662 offers two dynamic modes: internal function generation of standard functions like sine, square wave and triangle. The other mode is look-up table (LIST mode) output mode that can be used to output user defined voltage curves and positions with different sample times.

7.1 Internal Function Generator

The E-662 offers an internal function generator for standard periodic functions. The output function is determined by the shape (sine, triangle or square wave), the upper and lower amplitude and the frequency.

For triangle and square waves, the duty cycle can also be defined.

The following listings show how to start the internal function generator. All three different formats a, b and c perform the same functions:

SCPI-COMMAND **different formats:**	**Function**
a) SOURce:POSition:LEVel:IMMediate:AMPLitude 50.6 b) SOUR:POS:LEV:IMM:AMPL 50.6 c) POS 50.6	Sets the position to 50.6 microns. Also sets the servo-mode ON and selects the POS branch.
a) SOURce:POSition:LEVel:IMMediate:LOW 10 b) SOUR:POS:LEV:IMM:LOW 10 c) POS:LOW 10	Sets the lower amplitude for function generation to 10 microns
a) SOURce:POSition:LEVel:IMMediate:HIGH 70 b) SOUR:POS:LEV:IMM:HIGH 70 c) POS:HIGH 70	Sets the upper amplitude for function generation to 70 microns
a) SOURce:FREQency 50 b) SOUR:FREQ 50 c) FREQ 50	Selects a frequency of 50 Hz
a) SOURce:FUNCtion:SHAPe SINusoid b) SOUR:FUNC:SHAP SIN c) FUNC SIN	Starts the sine wave output

7.2 Dynamic LIST output

Dynamic operation is based on an internal look-up table where up to 200 output values can be stored in non-volatile EEPROM. During dynamic operation, the table values are read sequentially and forwarded to the DA converter which generates the dynamic output curve.

Stored table values can be output with a programmable static time base (minimum static time grid: 1 ms) or by an external trigger signal applied to the trigger input connector (maximum trigger frequency 500 Hz).

7.2.1 Loading the-Look-up Table

The command "DATA <index>,<value>" writes one output value to the table position <index>

Before beginning to store data values, the DATA:FLUSh command can be used to clear the table and resets the output mode (VOLT or POS).

The first data value (not necessarily list index 1) transferred to the table after the flush command, determines the output mode (VOLT or POS). Furthermore, the limit state at the time of writing the first table value determines the limits used for the table. If the servo-state is servo-OFF (can be achieved by issuing any VOLT xxx command) the table in initialized in VOLT mode. Any new values stored to any table index are interpreted as VOLT values.

If the servo-state is servo-ON (can be achieved with any POS xxx command) the table in initialized in POS mode. Any new values stored to any table index are interpreted as POSition values in µm. Again, the limit state when loading the first table value determines the limit state used for the entire table.

Data values in the table stay resident even if the device is shut off. After power on, the list output can be started and the servo-mode is set according to the table output mode.

Conversions are done during the download process. If data are downloaded in VOLT mode, VOLT branch calibration registers are used. In the POS mode the POS branch registers are used accordingly.

Example 1:

```
VOLT 0
DATA:FLUSH
DATA 1,0
DATA 2,2.8
...
DATA 25,1.5
```

Data values are interpreted as volts, processed by the calibration registers SOUR:VOLT:CAL:GAIN and SOUR:VOLT:CAL:OFFS.

Limits are taken into account: Only voltages within the programmed limits are stored, otherwise an error message placed on the error stack

Example 2:

```
POS 0
POS:LIM:STAT OFF
DATA:FLUSH
DATA 11,0
DATA 12,0.5
DATA 13,1.0
DATA 14,1.5
DATA 15,2.0
..
DATA 25,1.5
```

Data values are interpreted as POSitions in µm, µrad or mrad, processed by the calibration registers SOUR:POS:CAL:GAIN and SOUR:POS:CAL:OFFS.

Limits are not taken into account, because the limit control is turned off by command. Note that the DATA command transfers position data beginning with index 11.

7.2.2 Example for dynamic LIST output

List in POS mode (servo-ON)

```
POS 0
DATA:FLUSH
DATA 1,0
DATA 2,10.5
DATA 3,12
DATA 4,14.7
DATA 5,17
DATA 6,21
DATA 7,33
DATA 8,32
DATA 9,28.4
DATA 10,24
DATA 11,18
DATA 12,12
DATA 13,6
POS:MOD LIST
LIST:COUN 13
LIST:STAR
...
POS:MOD FIX
```

List in volt mode (servo-OFF)

```
VOLT 0
DATA:FLUSH
DATA 1,0
DATA 2,10
DATA 3,20
DATA 4,30
DATA 5,40
DATA 6,50
DATA 7,60
DATA 8,70
DATA 9,80
DATA 10,90
VOLT:MOD LIST
LIST:STAR
...
LIST:STOP 1
...
LIST:CONT 1
...
VOLT:MOD FIX
```

7.3 Trigger Option

External trigger capability for look-up table output is available as an option. TTL trigger signals can be used to step through the output table values. The trigger occurs at the edge of a low-to-high transition of the external signal.

An additional BNC socket labeled ´TRIGGER´ for trigger signal input is available on the modified rear panel of the E-662.

The trigger signal may have a maximum frequency of 500 Hz, that means that the minimum time delay of two consequent low-to-high transitions can be as short as 2 ms.

The trigger option requires the firmware version 1.2 or higher.

To enable trigger mode, the “sampletime” command has been modified by the addition of an additional parameter, "TRIG":

General Format:
DATA[:ATTRIBUTE]:SAMPletime {<value>|TRIG}"

Example:
Enable trigger mode: **DATA:SAMP TRIG**

8 E-662 Command Set

8.1 SCPI Conformity Information

Standard Commands for Programmable Instruments (SCPI) is an instrument command language for controlling instruments that goes beyond *IEEE 488.2* to address a wide variety of instrument functions in a standard manner. SCPI promotes consistency, from the remote programming standpoint, between instruments of the same class and between instruments with the same functional capability. For a given measurement function such as frequency or voltage, SCPI defines the specific command set that is available for that function. Thus, two oscilloscopes made by different manufacturers could be used to make frequency measurements in the same way. It is also possible for a SCPI counter to make a frequency measurement using the same commands as an oscilloscope.

SCPI commands are easy to learn, self-explanatory and lend themselves to use by both novice and expert programmers. Once familiar with the organization and structure of SCPI, considerable efficiency gains can be achieved during control program development, independent of the control program language selected.

The SCPI standard allows sending commands in long or short forms. The long form may be useful for compatibility with devices from other manufacturers. The short form, where all optional nodes of the command tree are omitted, performs the same function as the long form.

8.2 Command Survey (by type)

System Commands

`SYST:DEV:CONT {LOC|REM}`	Sets Local / Remote Mode
`SYST:DEV:CONT?`	Reads E-662 operational mode
`SYST:PZT?`	Reads PZT Actuator information
`SYST:DEV?`	Reads E-662 device information
`SYST:ERR?`	Reads the error message
`SYST:DEV:SERV?`	Reads servo-mode
`SYST:DEV:SERV:VOLT?`	Reads overflow status of servo-module
`SYST:VERS?`	Reads SCPI version number
`SYST:DEV:TEMP?`	Reads temperature status

Setting Voltages

SOUR:VOLT <value>	Sets output voltage and servo-OFF
SOUR:VOLT?	Reads commanded output voltage
SOUR:VOLT:REL {<value>|UP|DOWN}	Sets the output voltage relative
SOUR:VOLT:STEP {<value>|DEF}	Defines the step size

Setting Positions

SOUR:POS <value>	Sets absolute position and servo-ON
SOUR:POS?	Reads commanded output position
SOUR:POS:REL {<value>|UP|DOWN}	Sets the relative position
SOUR:POS:STEP {<value>|DEF}	Defines the position step size

Setting Limits

SOUR:VOLT:LIM:HIGH {<value>|DEF}	Defines the upper voltage limit
SOUR:VOLT:LIM:LOW {<value>|DEF}	Defines the lower voltage limit
SOUR:VOLT:LIM:STATE {ON|OFF}	Defines the voltage limit status
SOUR:POS:LIM:HIGH <value>	Defines the upper position limit
SOUR:POS:LIM:LOW <value>	Defines the lower position limit
SOUR:POS:LIM:STATE {ON|OFF}	Defines the position limit status

Dynamic Operation (Function Generator)

SOUR:FUNC {DC|SIN|SQU|TRI}	Defines the function
SOUR:FREQ <value>	Defines the frequency
SOUR:PULS:DCYC <value>	Sets the duty cycle
SOUR:VOLT:HIGH {<value>|DEF}	Sets the upper voltage amplitude of function
SOUR:VOLT:LOW {<value>|DEF}	Sets the lower voltage amplitude of function
SOUR:POS:HIGH <value>	Sets the upper position amplitude of function
SOUR:POS:LOW <value>	Sets the lower position amplitude of function

Dynamic Operation (Look-up Table output)

SOUR:VOLT:MODE {FIX|LIST}	Sets servo-off and enables table output
SOUR:VOLT:MODE?	Reads mode of VOLT branch
SOUR:POS:MODE {FIX|LIST}	Sets servo-on and enables table output
SOUR:POS:MODE?	Reads mode of POS branch
SOUR:LIST:STAR	Start list output
SOUR:LIST:STOP	Stop list output
SOUR:LIST:CONT	Continues list output, same phase
SOUR:LIST:COUNt <value>	Defines burst cycles
DATA <index>,<value>	Stores a value into the table at index
DATA?	Reads the current stored values from first to last.
DATA:FIRS<value>	Defines the first output index
DATA:LAST<value>	Defines the last output index
DATA:SAMP{<value>|TRIGger}	Defines the sample time or external trigger source
DATA:TYPE?	Reads the data type VOLT/POS and limits ON/OFF
DATA:FLUS	Clears the table

Status Commands

STAT:PRES	Reset enable register
STAT:OPER?	Reads SCPI operation register
STAT:OPER:COND?	Reads E-662 operation status register
STAT:OPER:ENAB<value>	Sets Enable Mask
STAT:OPER:ENAB?	Reads Enable Mask
STAT:QUES?	Reads SCPI Questionable Event Register
STAT:QUES:COND?	Reads Questionable status
STAT:QUES:ENAB	Sets Enable Mask
STAT:QUES:ENAB?	Reads Enable Mask

8.3 E-662 SCPI Command Reference

This table reflects all SCPI commands implemented in the E-662 Firmware Version 1.0. Bold parameters are power-on defaults. All commands complying with the SCPI standard are marked with SCPI.

Command	Parameter Format	Note	
[:SYSTem]			SCPI
:ERRor		[query only]	SCPI
[:NEXT]?		[query only]	SCPI
:VERSion?			SCPI
:PASSword			SCPI
:CDISable	<string>	[event, no query]	SCPI
[:CENable]	<string>	[event, no query]	SCPI
:STATe?		[query only]	SCPI
:PZT	<decimal_numeric>, <string>	password protected	
:DEVice	<decimal_numeric>, <string>	password protected	
:CONTrol	**LOCal**|REMote		
:TEMPerature?		[query only]	
:SERVo?		[query only]	
:VOLTage?		[query only]	
[:STATus]			SCPI
:PRESet	[event, no query]		SCPI
:OPERation			SCPI
[:EVENt?]		[query only]	SCPI
:CONDition?		[query only]	SCPI
:ENABable	<decimal_numeric>, range 0-65535, **(0)**		SCPI
:QUEStionable			SCPI
[:EVENt?]		[query only]	SCPI
:CONDition?		[query only]	SCPI
:ENABable	<decimal_numeric>, range 0-65535, **(0)**		SCPI
[:SOURCe]			SCPI
:VOLTage			SCPI
:MODe	**FIX**|LIST		SCPI
[:LEVel]			SCPI
[:IMMediate]			SCPI
[:AMPLitude]	<decimal_numeric> **(0.0)**, range 0-100		SCPI

:RELative	<decimal_numeric> |UP|DOWN **(0.0)**		
:HIGH	<decimal_numeric> |DEFault **(0.0)**		SCPI
:LOW	<decimal_numeric> |DEFault **(0.0)**		SCPI
:STEP	<decimal_numeric>|DEFault (non volatile), range 0-100		
:CALibrated			
:GAIN	<decimal_numeric> (non volatile)	password protected	
:OFFset	<decimal_numeric> (non volatile)	password protected	
:LIMit			SCPI
:HIGH	<decimal_numeric>|DEFault (non volatile)		SCPI
:LOW	<decimal_numeric>|DEFault (non volatile)		SCPI
:STATe	<decimal_numeric> **(1)**|ON|OFF		SCPI
:POSition	<decimal_numeric>		
:MODe	**FIX**|LIST		
[:LEVel]			
[:IMMediate]			
[:AMPLitude]	<decimal_numeric> **(0.0)**		
:RELative	<decimal_numeric> |UP|DOWN **(0.0)**		
:HIGH	<decimal_numeric> **(0.0)**		
:LOW	<decimal_numeric> **(0.0)**		
:STEP	<decimal_numeric> (non volatile)		
:CALibrated			
:GAIN	<decimal_numeric> (non volatile)	password protected	
:OFFset	<decimal_numeric> (non volatile)	password protected	
:LIMit			
:HIGH	<decimal_numeric> (non volatile)		
:LOW	<decimal_numeric> (non volatile)		
:STATe	<decimal_numeric>|ON|OFF (**1**|ON)		
:FUNCtion			SCPI
[:SHAPe]	**DC**|SINusoid|SQUare |TRIangle		SCPI

:FREQuency			SCPI
[:FIXed|:CW]	<decimal_numeric> **(0.0)**, range 0-150		SCPI
:PULSe			SCPI
:DCYCle	<decimal_numeric> **(50.0)**, range 0-100		SCPI
:LIST			
:STARt		[event, no query]	
:STOP		[event, no query]	
:CONTinue		[event, no query]	
:COUNt	<decimal_numeric> **(-1)** range -1 - 2.000.000.000		SCPI
:DATA	<decimal_numeric>,<decimal_numeric>	(non volatile)	
[:ATTribute]			
:FIRSt	<decimal_numeric> **(1)**		
:LAST	<decimal_numeric> **(200)**		
:SAMPletime	<decimal_numeric> **(1)** range 1 - 2.000.000.000		
:TYPE?		[query only]	
:FLUSh			

8.4 IEEE Mandated Commands

E-662 also handles common commands declared mandatory for conformance to IEEE 488.2.

KEYWORD	PARAMETER FORM	NOTES
*CLS	[event, no query]	SCPI
*ESE	<decimal_numeric>, range 0-255	SCPI
*ESR?	[query only]	SCPI
*IDN?	[query only]	SCPI
*OPC		SCPI
*RST	[event, no query]	SCPI
*SRE	<decimal_numeric>, range 0-255	SCPI
*STB?	[query only]	SCPI
*TST?	[query only]	SCPI
*WAI	[event, no query]	SCPI

8.5 Command Reference (by type)

8.5.1 System Commands

[SYST:]DEV:CONT {LOC|REM}

Function:	Sets the E-662 to local mode (front panel control) or remote mode (interface control).	
Example:	Long form:	**[SYSTem:]DEVice:CONTrol LOC**
	Short form:	**DEV:CONT LOC** **DEV:CONT REM**
Query:	Long form:	**[SYSTem:]DEVice:CONTrol?**
	Short form:	**DEV:CONT?**
Report string:	"Local frontpanel control"|"Remote interface command control"	

[SYST:]PZT?

Function:	The original SYST:PZT command is password protected and writes the serial number and type of the PZT actuator. The query command allows to read the information.	
Example:	Long form:	**[SYSTem:]PZT?**
	Short form:	**PZT?**
Report string:	"0999, PZT_type"	

[SYST:]DEV?

Function:	The original SYST:DEV command is password protected and writes the serial number and type of the electronic module and calibration date. The query command allows to read that information.	
Example:	Long form:	**[SYSTem:]DEV?**
	Short form:	**DEVice?**
Report string:	"Electronic_#, Electronic_type, Cal_date"	

[SYST:]ERR?

Function:	This query command reads the error number and error description of the oldest error occured (FIFO).	
Example:	Long form:	**[SYSTem:]ERRor?**
	Short form:	**ERR?**
Report string:	"error_code, "error description"	

[SYST:]DEV:SERV?

Function:	This command reads the current servo-status. The servo-status corresponds with a hardware switch in the servo-control module. The switch is operated automatically: sending a VOLT-branch command the switch is set to servo-OFF, any POS-branch commands set servo-ON. If the E-662 is set to local mode, the DEV:SERV? query reflects the position of the toggle switch 'open-loop' or 'closed-loop'.	
Example:	Long form:	**[SYSTem:]DEVice:SERVo?**
	Short form:	**DEV:SERV?**
Report string:	"Servo-off"|"Servo-on"	

[SYST:]DEV:SERV:VOLT?

Function:	This command reads the overflow status of the servo-module.	
Example:	Long form:	**[SYSTem:]DEVice:SERVo:VOLTage?**
	Short form:	**DEV:SERV:VOLT?**
Report string:	"In Range"|"Voltage overflow"	

[SYST:]DEV:SERV:TEMP?

Function:	This command reads the temperature of the device power amplifiers.	
Example:	Long form:	**[SYSTem:]DEVice:SERVo:TEMPerature?**
	Short form:	**DEV:SERV:TEMP?**
Report string:	"Normal Temp"|"Temp out of range"	

[SYST:]VERS?

Function: This command reads the version information

Example: Long form: **[SYSTem:]VERSion?**

Short form: **VERS?**

Report string:

8.5.2 Setting Voltages

[SOUR:]VOLT <value>

Function: Sets the output voltage in V. Checks the parameter for voltage limits. Sets the Servo-off mode.

Example: Long form: **[SOURce:] VOLTage [:AMPLitude] 23.45**

Short form: **VOLT 23.45**

Query: **SOURce:VOLTage?**
VOLT?
The query command reads the actual commanded output voltage. Due to internal rounding, the reported value may not correspond exactly with the programmed value in all decimal digits.

[SOUR:]VOLT:REL <UP|DOWN|value>

Function: Sets the output voltage relative to the current level for one increment up or down. If a <value> is given, the given value is added to the current output.

Examples: Long form: **SOURce:VOLTage:RELative 7.5**

Short form: **VOLT:REL 7.5**
VOLT:REL UP
VOLT:REL DOWN

Query: **SOUR:VOLT:REL?**
VOLT:REL?

[SOUR:]VOLT:STEP <value>

Function: Defines the voltage increment size and stores the value in non volatile memory. The value is used with the VOLT:REL UP|DOWN command.

Examples: Long form: **SOURce:VOLTage:LEVel:IMMediate:STEP 10**

Short Form: **VOLT:STEP 10**

Query: **SOUR:VOLT:STEP?**
VOLT:STEP?

8.5.3 Setting Positions

[SOUR:]POS <value>

Function: Sets the PZT displacement of the activated channel in micrometers. Enables the servo-loop.

Example: Long form: **SOURce:POSition:AMPLitude 23.45**

Short form: **POS 23.45**

Query: **SOUR:POS?**
POS?
The query command reads the actual commanded output position. Due to internal rounding, the reported value may not correspond exactly with the programmed value in all decimal digits.

[SOUR:]POS:REL <UP|DOWN|value>

Function: Sets the PZT displacement relative to the current position for one increment up or down. If a <value> is given, the given value is added to the current position.

Examples: Long form: **SOURce:POSition:RELative 1.5**

Short form: **POS:REL 1.5**
POS:REL UP
POS:REL DOWN

Query: **SOUR:POS:REL?**
POS:REL?

[SOUR:]POS:STEP <value>

Function: Defines the displacement increment size and stores the value in non volatile memory. The value is used with the POS:REL UP|DOWN command.

Examples: **SOUR:POS:STEP 10**
POS:STEP 10

Query: **SOUR:POS:STEP?**
POS:STEP?

8.5.4 Setting Limits

[SOUR:]VOLT:LIM:HIGH <DEF|value>

Function: Defines the upper voltage limit. Any command that tries to set the voltage beyond that limit is not executed and the error flag is set if VOLT:LIM:STAT is ON.

Example: **SOUR:VOLT:LIM:HIGH 80**
VOLT:LIM:HIGH 80
SOUR:VOLT:LIM:HIGH DEF
VOLT:LIM:HIGH DEF

Query: **SOUR:VOLT:LIM:HIGH?**
VOLT:LIM:HIGH?

[SOUR:]VOLT:LIM:LOW <DEF|value>

Function: Defines the lower voltage limit. Any command that tries to set the voltage below that limit is not executed and the error flag is set if VOLT:LIM:STAT is ON.

Example: **SOUR:VOLT:LIM:LOW 80**
VOLT:LIM:LOW 80
SOUR:VOLT:LIM:LOW DEF
VOLT:LIM:LOW DEF

Query: **SOUR:VOLT:LIM:LOW?**
VOLT:LIM:LOW?

[SOUR:]VOLT:LIM:STAT <value|ON|OFF>

Function: Sets the limit control status for voltages. This status defines whether or not voltage limits are checked and commands refused trying to set voltages beyont the programmed limits. The status can be ON (=1) or OFF (=0).

Examples:
SOUR:VOLT:LIM:STAT 1|0
VOLT:LIM:STAT 1|0
SOUR:VOLT:LIM:STAT ON|OFF
VOLT:LIM:STAT ON|OFF

Query:
SOUR:VOLT:STAT??
VOLT:LIM:STAT?

Report: "Voltage limits ON" | "Voltage Limits OFF"

[SOUR:]POS:LIM:HIGH <value>

Function: Defines the upper position limit. Any command that tries to set the position beyond that limit is not executed and the error flag is set.

Example:
SOUR:POS:LIM:HIGH 12
POS:LIM:HIGH 12
SOUR:POS:LIM:HIGH DEF
POS:LIM:HIGH DEF

Query:
SOUR:POS:LIM:HIGH?
POS:LIM:HIGH?

[SOUR:]POS:LIM:LOW <value>

Function: Defines the lower position limit. Any command that tries to set the position below that limit is not executed and the error flag is set.

Example:
SOUR:POS:LIM:LOW 80
POS:LIM:LOW 80
SOUR:POS:LIM:LOW DEF
POS:LIM:LOW DEF

Query:
SOUR:POS:LIM:LOW?
POS:LIM:LOW?

[SOUR:]POS:LIM:STAT <value|ON|OFF>

Function: Sets the limit control status for positions to ON or OFF. Besides the ON and OFF tokens also boolean values 0=ON or NOT 0 = OFF can be used.

Examples:
SOUR:POS:LIM:STAT
POS:LIM:STAT
SOUR:POS:LIM:STAT ON|OFF
POS:LIM:STAT ON|OFF

Query:
SOUR:POS:LIM:STAT??
POS:LIM:STAT?

Report: "POSition limits ON" | "POSition Limits OFF"

8.5.5 Dynamic Operation (Function Generator)

[SOUR:]FUNC {DC|SIN|SQU|TRI}

Function: Sets the function type for the active POS or VOLT branch. Option are sine(SIN), square wave(SQU) or triangle(TRI). The output starts immediately with the set frequency and amplitudes set by HIGH and LOW of the active branch.

Examples:
SOUR:FUNC SIN
FUNC SIN

Query:
SOUR:FUNC?
FUNC?

[SOUR:]FREQ <value>

Function: Sets the output frequency of the function generator for the next FUNC call. If the function output is active, the frequency of the current output function is changed. The frequency programmed is valid for the POS and the VOLT branch.

Range: 0 - 150, default: 0.0,
recommended maximums: SIN,TRI: 50 Hz, SQU:100 Hz
Sample time: 3 ms

Examples:
SOUR:FREQ 5
FUNC SIN

Query:
SOUR:FREQ?
FREQ?

[SOUR:]PULS:DCYC <value>

Function: Sets the relation of High and Low within a period of Square and Triangle output functions. This duty cycle is given in percent and can be used while the function output is active.

Range: 0 - 100, default: 50

Examples: **SOUR:PULS:DCYC 75**
PULS:DCYC 75

Query: **SOUR:PULS:DCYC?**
PULS:DCYC?

[SOUR:]VOLT:HIGH {<value>|DEF}

Function: Sets the upper output voltage (most positive voltage) of the function generator output when working in VOLT mode.
If the token DEF is used, the value is set to 100. The value programmed has to be larger (more positive) than the value for VOLT:LOW.
This command can be send during the function generator is active to change the upper output voltage.

Examples: **SOUR:VOLT:HIGH 90** sets max. amplitude to 90 volts
VOLT:HIGH 90

Query: **SOUR:VOLT:HIGH?**
VOLT:HIGH?

[SOUR:]VOLT:LOW {<value>|DEF}

Function: Sets the lower output voltage (least positive voltage) of the function generator output when working in VOLT mode.
If the token DEF is used, the value is set to 0. The value programmed has to be smaller (less positive) than the value for VOLT:HIGH.
This command can be send during the function generator is active to change the upper output voltage.

Examples: **SOUR:VOLT:LOW 10** sets lower amplitude to 10 volts
VOLT:LOW 10

Query: **SOUR:VOLT:LOW?**
VOLT:LOW?

[SOUR:]POS:HIGH <value>

Function: Sets the upper PZT position (largest displacement) of the function generator output when working in POS mode.
The value programmed has to be larger than the value for POS:LOW.
This command can be used while the function generator is active to change the upper displacement level.

Examples: **SOUR:POS:HIGH 45** sets max. amplitude to 90 volts
POS:HIGH 45

Query: **SOUR:POS:HIGH?**
POS:HIGH?

[SOUR:]POS:LOW <value>

Function: Sets the lower PZT position (smallest displacement) of the function generator output when working in POS mode.
The value programmed has to be smaller than the value for POS:HIGH.
This command can be used while the function generation is active to change the lower displacement level.

Examples: **SOUR:POS:LOW 10** sets lower amplitude to 10 volts
POS:LOW 10

Query: **SOUR:POS:LOW?**
VPOS:LOW?

8.5.6 Dynamic Operation (Look-Up Table)

[SOUR:]VOLT:MODE {FIX | LIST}

Function: Sets the mode of the VOLT branch: Parameter LIST switches to list output operation, FIX selects normal operation and restores the last output in the VOLT mode. The LIST mode is enabled only if the DATA table is loaded with VOLT values.

Parameters: FIX: enables "normal" operation
LIST: enables DATA table output

Example: **SOUR:VOLT:MODE FIX**

Query: **SOUR:VOLT:MODE?**

[SOUR:]POS:MODE {FIX | LIST}

Function:	Sets the mode of the POS branch: Parameter LIST switches to list output operation, FIX selects normal operation and restores the last output in the POS mode. The LIST mode is enabled only if the DATA table is loaded with POS values.
Parameters:	FIX: enables "normal" operation LIST: enables DATA table output
Example:	**SOUR:POS:MODE FIX**
Query:	**SOUR:POS:MODE?**

DATA <index>, <value>

Function:	The DATA command writing data into the look-up table. This command is required once for each data point.
Parameters:	<index > is an integer in the range 1 - 200 and represents the table index to which the value is written to. <value> is a floating point number representing either position or voltage depending on the setting.
Example:	DATA 43,17.4
Query:	DATA? The query command reads the set values starting at index FIRS and ends at index LAST. This is the only E662 command performing last-first communcation cycles.

DATA:FIRS <first index>

Function:	Defining the register *First Index*. First Index is the index of the first data value that is output when a scan is started. As default, first index is 1.
Example:	**DATA:FIRS 10**
Query	**DATA:FIRS?**

DATA:ATTR:LAST <last index>

Function:	Defining the register *Last Index*. Last Index is the index of the last data value that is output when a scan is started.
Default:	200
Example:	**DATA:LAST 100**
Query	**DATA:LAST?**

DATA:ATTR:SAMP {<sample time>|TRIG}

Function: Defining the register *Sample Time or defines an external signal as trigger*. The sample time defines the time grid used for output table values. As default, the sample time is set to 1 ms. When the TRIG parameter is applied, the output table is accessed by external TTL trigger signals. Each low-to-high transition outputs the next table value.

Examples:
DATA:SAMP 1000
DATA:SAMP TRIG

Range: In steps of 1 ms the sample time can be increased from 1 ms to 2,000,000,000.

DATA:FLUS

Function: Clears the table. The first DATA value after DATA:FLUS defines the POS/VOLT mode of the table and the limit control status.

DATA:TYPE?

Function: Reads the way DATA values are stored in the table (POS|VOLT) and the status of the limit control.

[SOUR:]LIST:START

Function: Starts dynamic output
The first value output has the index defined by DATA:ATTR:FIRS.

The START command set the servo-ON/OFF mode according to the values stored in the list.

[SOUR:]LIST:STOP

Function: Stops dynamic output.

[SOUR:]LIST:CONT

Function: Resumes dynamic output.
CONT resumes dynamic output with the current set index position.
Using CONT, a function curve can be output starting with the next index as it was stopped by the STOP command.
Unlike CONT, the START command starts the list output always at index FIRS.

[SOUR:]LIST:COUN <cycles>

Function: Starts a defined number of cycles.
The default value is -1 and is interpreted as continuous dynamic output.

Range: Any numbers in the range of -1 to 2,000,000,000

8.5.7 Status Commands

[STAT:]PRES

Function: Resets the device-independant enable register OPERation enable and QUEStionable enable registers.

[STAT:]OPER?

Function: Reads the 16 bit SCPI operation event register. This register shows events of the OPER condition register, that means any bit changes (Low/High and High/Low events) are indicated.

[STAT:]OPER:COND?

Function: Reads the E-662 Operation status (condition) register. This register shows states like Calibration and Range. E-662 reports always zero.

[STAT:]OPER:ENAB

Function: Sets the enable mask for setting the OPER_event summary bits in the status byte (bit 7).

[STAT:]OPER:ENAB?

Function: Reads the mask of the OPER_event register.

[STAT:]QUES?

Function: Reads the SCPI Questionable 16 bit event register. This register shows events of the QUES Condition registers, that are any Low/HIgh and High/Low changes in the related bits.

[STAT:]QUES:COND?

Function: Reads the E-662 Questionable status. This status indicates whether values like Volt or Freq can be read.

[STAT:]QUES:ENAB

Function: Sets the enable mask for setting the QUES_event summary bits in the status word (bit 3).

[STAT:]QUES:ENAB?

Function: Reads the mask enable registerof the Questionable event register.

9 Status Reporting

SCPI requires a status mechanism, including event status register structure. The E-662 offers the IEEE488.2 status register, the Queriable and the Operation status register. All registers are supported by event and enable registers.

Registers Supported by the E-662:

Register	Read Commmand	Set and Clear Command	Clear Command
IEEE488.2 (8 Bit Register):			
Status Byte Register	*STB?	Firmware	*CLS
Service Request Enable Register	*SRE?	*SRE	*SRE 0
Standard Event Register	*ESR?	Firmware, no clear	*ESR?, *CLS
Standard Event Status Enable Register	*ESE?	*ESE	*ESE 0
SCPI (16 Bit Register):			
OPERation Condition Register	OPER:COND?	Firmware	
OPERation Event Register	OPER?	Firmware, no clear	OPER?, *CLS
OPERation Event Enable Register	OPER:ENAB?	OPER:ENAB	OPER:ENAB, STAT:PRESet
QUEStionable Condition Register	QUES:COND?	Firmware	
QUEStionable Event Register	QUES?	Firmware, no clear	OPER?, *CLS
QUEStionable Event Enable Register	QUES:ENAB?	QUES:ENAB	QUES:ENAB, STAT:PRESet

General register handling:

Status/Condition Registers:	Non-destructive read, set/reset by firmware
Event Registers:	Destructive read, set by firmware, reset by read
Enable registers:	Write/Read by commands, clear by set to zero

9.1 IEEE488.2 and SCPI Status Registers

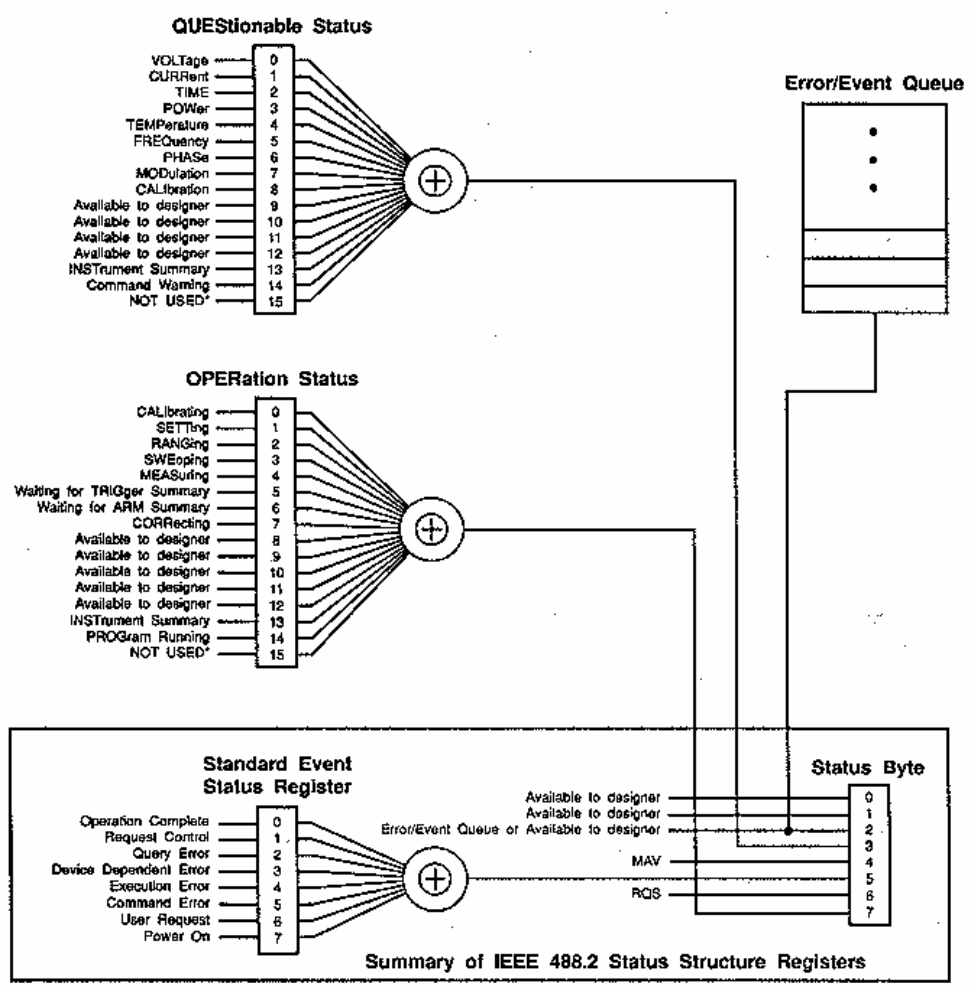

Fig. 2: 1995 SCPI Syntax & Style

** The use of Bit 15 is not allowed since some controllers may have difficulty reading a 16 bit unsigned integer. The value of this bit shall always be 0.*

10 E-662.xx Technical Data

10.1 Specifications

Function:	Power amplifier and position servo-controller for LVPZTs
Channels:	1

Amplifier:

Voltage output range:	-20 to +120 V (local mode) 0 to +100 V (remote mode)
Max. output power:	36 W
Average output power:	12 W
Peak output current:	360 mA (for 5 ms)
Current limitation:	short-circuit proof
Voltage Gain:	10 +-0.1
Polarity:	positive
Control Input Voltage:	-2 to +12 V
DC offset setting:	0 to +100 V with 10-turn potentiometer
Input Impedance:	100 kOhm
Display:	2 x 3½ digits, LED
Control input socket:	BNC
PZT voltage output socket:	LEMO ERA.00.250.CTL
Dimensions:	274 (321 with handles) x 235 x 88 mm
Weight:	2.5 kg
Operating Voltage:	90-120/220-240 VAC, 50-60 Hz

Position Servo-Control

Sensor Types:	Strain Gauge (E-662.SR), LVDT (E-662.LR)
Servo-Characteristic:	P-I-analog
Sensor Socket:	LEMO ERA.0S.304.CLL
Sensor monitor output socket:	BNC

D/A Converter and Computer Interface:

Interface:	RS-232
Resolution:	12-bit (2.5 mV input)

10.2 Dimensions

There are 4 rubber feet on the bottom (not shown) which each have a height of 6 mm. They can be removed if desired.

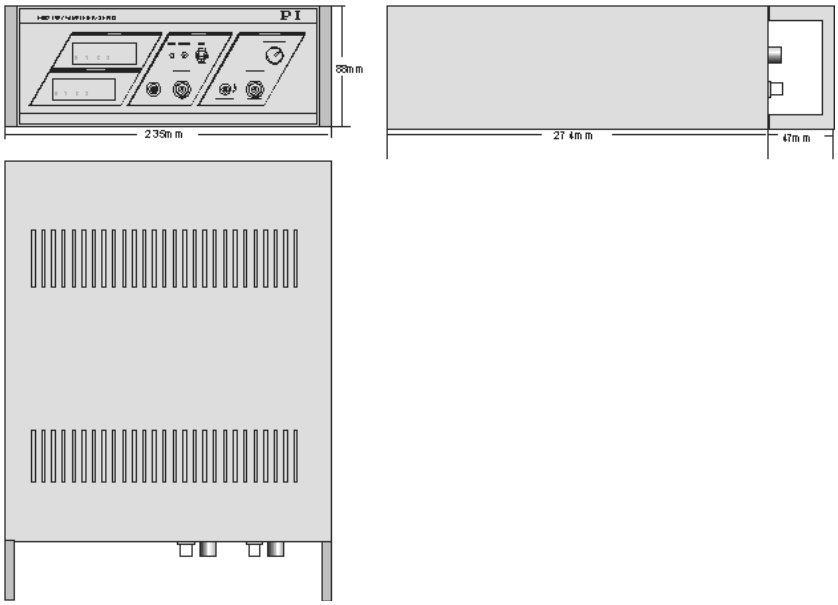

Fig. 3: E-662 Dimensions

10.3 Line Power and Fuses

The power connection, input voltage selection and line fuses are located on the rear panel. Unless you request otherwise, the unit will be set up for the line voltage we believe predominant in your country.

New Fuses Required when Changing Supply Voltage

To connect the product to a different supply voltage, it is necessary not only to reorient the fuse carrier so that the desired voltage is visible in the window, but also to replace both the line fuses with the value appropriate for the new voltage.

Lower supply voltage requires higher current.

To access the fuse carrier, remove the power cord, and pry open the door that covers the carrier. The carrier can then be pried out, exposing the two line fuses (see illustration at right).

After replacing the fuses, reinstall the carrier in the new orientation; check that the correct voltage setting is visible through the window in the door when it is reclosed.

Fig. 4: Fuse location (1 of 2 fuses visible) and line voltage setting

Voltage setting & fuse values:

115 V: 1.6 A*
230 V: 0.8 A*

* slow blow fuses required

10.4 Frequency Response

E-662 open-loop frequency response with various PZT loads. Capacitance values are in µF.

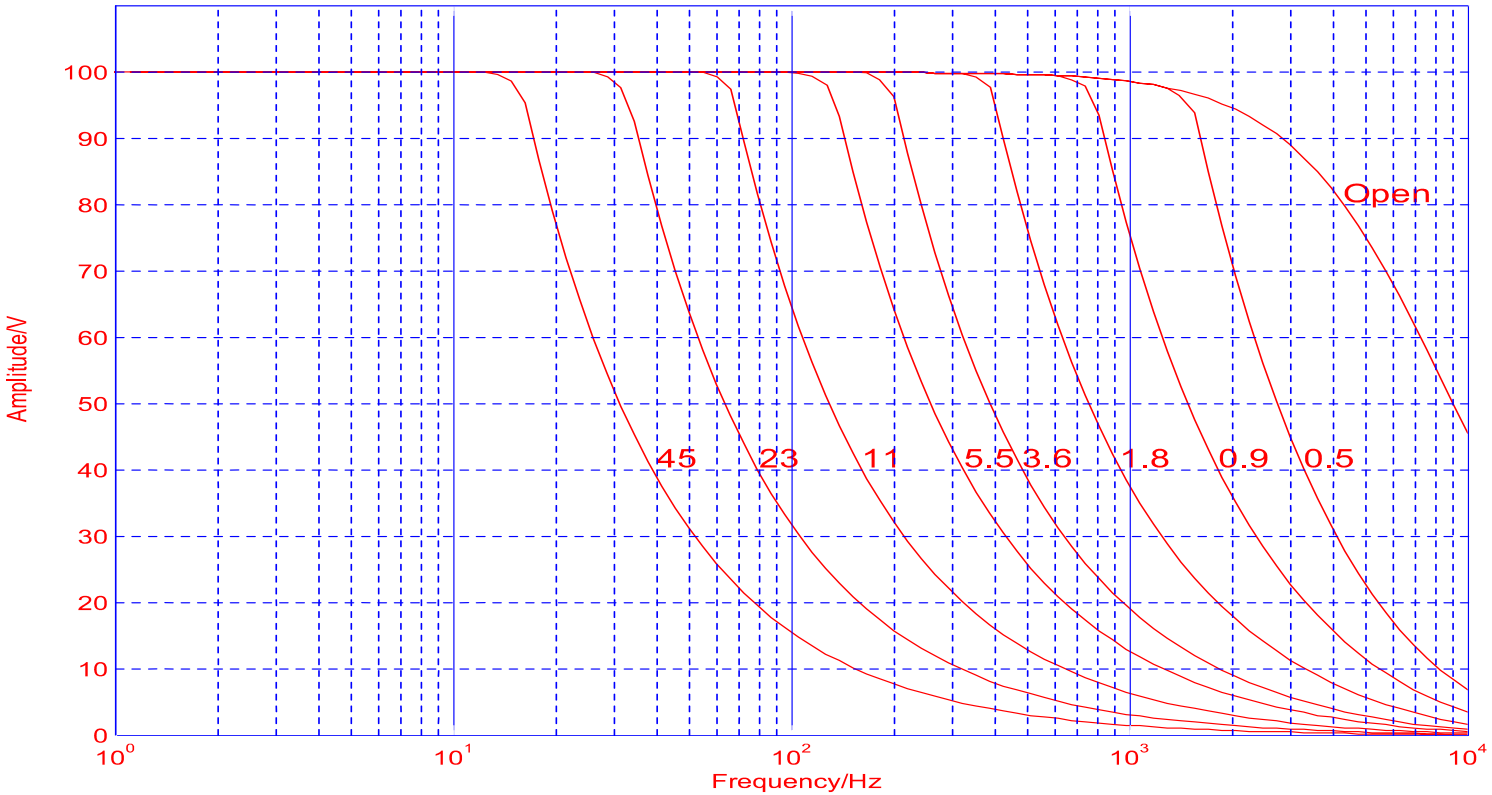

Fig. 5: Frequency Response