Instruction Manual
Digital Piezo Amplifier
Series NPCxxxDIG
Models:
NPC50DIG & NPC300DIG

Please read carefully before switching on the power! Please see safety instructions for using piezoelectric actuators and power supplies!

CE

English version: last change 2017-02-16 by TP

1. Table of contents

1 Introduction

This manual describes the digital piezo amplifier series ***NPCxxxDIG*** from ***Newport Corporation***. You will also find additional information regarding piezoelectric products.

Definition: All systems from ***Newport Corporation*** such as electronics, actuators, and optical systems are called “units”.

If you have any problems please contact the manufacturer of the system: ***Newport Corporation***, 1791 Irvine Ave. Irvine, CA 92606. Phone: (877) 835-9620

2 Certification of Newport Corporation

The company ***Newport Corporation*** works in according to an ISO 9001:2008 certified quality management system. Its effectiveness is verified and proven by periodic audits by the BSI. Our certificate can be found at Newport.com

This instruction manual includes important information for using piezo actuators. Please take the time to read this information. Piezo positioning systems are mechanical systems that offer the highest precision. Correct handling guarantees that this precision will be maintained over a long period of time.

3 Declaration of Conformity

EU Declaration of Conformity

Product Name: Digital Piezo Amplifier

Model Number: NPCxxxDIG

Year CE mark affixed: 2016

Type of Equipment: Electrical equipment for measurement, control and laboratory use in industrial locations.

Manufacturer: Newport Corporation
1791 Deere Avenue
Irvine, CA 92606
U.S.A.

We hereby certify that the above described device in its conception, construction and form put by us into circulation is in accordance with all relevant essential requirements of the EMC Directive 2014/30/EU. This declaration is no longer valid if the device is modified without our consent.

The agreement with further valid guideline / regulations following for the product is explained:

Low Voltage Directive: 2014 / 35 / EU

EMC Directive: 2014 / 30 / EU

DIN EN 61010-1:2011

I, the undersigned, hereby declare that the equipment specified above conforms to the above Directives and Standards.

Gwen Briens

Sr. Director, Motion and Instruments Business

Newport Corporation

1791 Deere Ave, Irvine, CA92606 USA

4 Purchased Part Package

- Please check the completeness of the delivery after receiving the shipment:

- piezo amplifier ***NPCxxxDIG***
- wide range power supply 24 V DC
- RS232 cable
- USB cable
- instruction manual
- CD-ROM with driver, software, and instruction manual

5 Instructions for using piezo electrical elements and power supplies

- Piezoelectric actuators from ***Newport Corporation*** are controlled by voltages up to 150 V. These values can be quite hazardous. Therefore, read the installation instructions carefully and ensure that only authorized personnel handle the power supply.
- After transportation, piezoelectric actuators should be allowed to adapt to room temperature for approximately 2 hours before being switched on.
- Piezoelectric actuators are made from ceramic materials with and without metallic casings. The piezo-ceramic is a relatively brittle material. This should be noted when handling piezoelectric actuators. All piezo elements are sensitive to bending or shock forces.
- Due to the piezoelectric effect, piezo actuators can generate electrical charges by changing the mechanical load or the temperature, or by actions such as the ones described above.
- Piezoelectric actuators are able to work under high compressive forces. Only actuators with a pre-load can be used under tensile loads (these tensile forces must be less than the pre-load given in the data sheet). Please note that acceleration of the ceramic material (e.g., caused by fall down, discharging, or high dynamic application) will occur.
- After excitation of the actuators by a voltage in the upper control range, the ceramic will move and generate an opposite high voltage after disconnection.
- Heating of the ceramic material will occur during dynamic operation and is caused by structure conditional loss processes. This may cause failure if the temperature exceeds specified values cited below. With increasing temperature up to the Curie temperature T_C, (usual values approx. 140°C - 250°C) the piezoelectric effect disappears. We recommend working in temperatures up to $T_C/2$ (normally up to 80°C).
- Piezoelectric actuators, such as stacks or other devices, work electrically as a capacitor. These elements are able to store electrical energy over a long period of time (up to some days) and the stored energy may be dangerous.
- If the actuator remains connected to the drive electronics, it will be unloaded within a second after shutdown and quickly reaches harmless voltage values.
- Piezo actuators can only generate voltages by warming or cooling (caused by the longitudinal change). The discharge potential should not be ignored due to the inner capacitance. This effect is insignificant at usual room temperature.
- Piezo actuators from ***Newport Corporation*** are adjusted and glued. Any opening of the unit will cause misalignment or possible malfunction and will result in the loss of the guarantee..
- Please only use original parts from ***Newport Corporation***.
- Please contact ***Newport Corporation*** or your local representative if there are any problems with your actuator or power supply.

Caution! Shock forces may damage the built-in ceramic elements. Please avoid such forces, and handle the units with care, otherwise the guarantee will be lost.

6 Safety instructions

Icons:

European Union CE Mark

CE Mark

The presence of the CE Mark on New Focus equipment means that this instrument has been designed, tested and certified compliant to all applicable European Union (CE) regulations and recommendations.

Waste Electrical and Electronic Equipment (WEEE)

WEEE Directive Symbol

This symbol on the product or on its packaging indicates that this product must not be disposed with regular waste. Instead, it is the user responsibility to dispose of waste equipment according to the local laws. The separate collection and recycling of the waste equipment at the time of disposal will help to conserve natural resources and ensure that it is recycled in a manner that protects human health and the environment. For information about where the user can drop off the waste equipment for recycling, please contact your local Newport representative.

Control of Hazardous Substances

RoHS Compliant Symbol

This label indicates the products comply with the EU Directive 2011/65/EC that restricts the content of six hazardous chemicals.

RISK OF ELECTRIC SHOCK! Indicates that a risk of electric shock is present and the associated warning should be observed.

CAUTION! REFER TO OPERATOR´S MANUAL – Refer to your operator's manual for additional information, such as important operating and maintenance instructions.

RISK OF ELECTRIC SHOCK!

- Do not open the units! There are no user serviceable parts inside and opening or removing covers may expose you to dangerous shock hazards or other risks. Refer all servicing to qualified service personnel.
- Do not spill any liquids into the cabinet or use the units near water.

CAUTION!

- Allow adequate ventilation around the units so that heat can properly dissipate. Do not block ventilated openings or place the units near a radiator, oven, or other heat sources. Do not put anything on top of the units except those that are designed for that purpose (e.g. actuators).
- Only work with the units in a clean and dry environment! Only specially prepared units (e.g. actuators) can work under other conditions!
- Please only use original parts from ***Newport Corporation***. ***Newport Corporation*** does not give any warranty for damages or malfunction caused by additional parts not supplied by ***Newport Corporation***. Additional cables or connectors will change the calibration and other specified data. This can change the specified properties of the units and cause them to malfunction.
- Piezo elements are sensitive systems capable of the highest positioning accuracy. They will demonstrate their excellent properties only if they are handled correctly! Please mount them properly at the special mounting points.

Immediately unplug your unit from the wall outlet and refer servicing to qualified service personnel under the following conditions:

- when the cords or plugs are damaged
- if liquid has been spilled or objects have fallen into the unit
- if the unit has been exposed to rain or water
- if the unit has been dropped or the housing is damaged

6.1 Installation, power supply

RISK OF ELECTRIC SHOCK 

- Do not insert or unplug the power plug with wet hands, as this may result in electrical shock.
- Do not install in rooms where inflammable substances are stored. If flammable substances come into contact with electrical parts inside, it could result in fire or electrical shock.
- Do not damage or modify the power cord. Also, do not place heavy objects on the power cord, or pull on or excessively bend it, as this could cause electrical damage and result in a fire or electrical shock.
- Always grasp the plug portion when unplugging the power cord. Pulling on the power cord may expose or snap the core wire, or otherwise damage the power cord. If the cord is damaged, this could cause an electricity leak and result in a fire or electrical shock.

CAUTION! 

- Do not use accessories other than the ones provided (e.g. power cord). Only plug the power cord into grounded power equipment and sockets.
- Do not place heavy objects on any cables (e.g. power cords, sensor cables, actuator cables, optical cables).
- Do not block ventilated openings or place the units near a radiator, oven, or other heat sources.
- Plug in the power cord completely so that it cannot loosen inadvertently.
- Leave sufficient space around the power plug so that it can be unplugged easily. If objects are placed around the power plug, you will be unable to unplug it in an emergency.
- Install the system so that the on/off-switch is easily accessible at all times.
- The power plug is the cut-off point to the main power supply.

6.2 Operation

RISK OF ELECTRIC SHOCK! 

- Do not open the units! There are no user serviceable parts inside and opening or removing covers may expose you to dangerous shock hazards or other risks. Refer all servicing to qualified service personnel.
- Do not spill inflammable substances inside the voltage amplifier. If these items come into contact with an electrical component inside the voltage amplifier, this may result in a fire or electrical shock.

CAUTION! 

- If the voltage amplifier emits smoke, high heat, or unusual smells, immediately turn off the power switch and unplug the power plug from the outlet. Then contact our technical service.

6.3 Maintenance and Inspection

CAUTION! ⚠

- Before cleaning the exterior box of the voltage amplifier, turn off the power switch and unplug the power plug. Failure to do so may result in a fire or electrical shock.
- Clean the exterior box using a damp cloth that has been firmly wrung-out. Do not use alcohols, benzene, paint thinner or other inflammable substances. If flammable substances come into contact with an electrical component inside the voltage amplifier, this may result in a fire or electrical shock.

6.4 Environmental Conditions

The amplifier can be used:

- indoors only
- at an altitude of up to 2000 m
- at a temperature between: 5...35 °C
- at a relative humidity between: 5...95% (non-condensing)

The recommended environmental conditions:

- indoors only
- at an altitude of up to 2000 m
- at a temperature between: 20...22 °C
- at a relative humidity between: 5...80% (non-condensing)

7 Instructions for checking the function of the system / quick start

When you open the package, please check to make sure all the necessary parts are included (see packing list) and nothing is damaged. Check the electronics and the actuator for any visible damage:

- The top and bottom plates of the actuator (if it does not have another shape) should be parallel each to each other and not have any scratches.
- If there is any damage to the system please contact our local representative immediately!
- If the packaging material is damaged please confirm this with the shipping company.
- Ensure that the main voltage supplied in your country is the same as the one installed in the system (Check the voltage label on the backside of the power supply).
- The power switch should be in the off position.
- Connect the power supply.
- Connect the piezo actuator by using the D-SUB 15pin connector. Be sure the cables are connected properly to the electronics.
- Turn the system on by using the POWER switch on the Front panel. The green
- “READY” LED indicates that the power supply is working. It is followed by a short self test.
- The yellow LED’s ”OVL” and “UDL” will blink. The green “OL/CL” LED shines permanently. If there is an actuator plugged into the D-SUB 15pin and the amplifiers are working, the LED's will switch off after about 3 seconds.
- Switch on closed loop by pressing on the encoder knob. The OL/CL LED will shine yellow. Turn the knob to the left until the minimum position (0 µm) is reached and switch off the closed loop.
- Now you can set the position with the “OFFSET” encoder knob.
- If the UDL/OVL-LED lights up there is an error. In this case please read the chapter on *troubleshooting.* Please switch off the device.
- The function check is complete.

8 How to operate the digital amplifier series NPCxxxDIG

8.1 Common Introduction

Our line of digital piezo amplifiers d-Drive from ***Newport Corporation*** has now been expanded with the addition of the OEM amplifier series ***NPCxxxDIG*** including ***NPC300DIG*** with 300mA output current. These amplifiers are designed for use as a single unit in industrial settings. It is compact, robust, and mountable in different manners and is highly reliable. The ***NPCxxxDIG*** was designed for universal use with a wide main supply voltage from 10V to 30V DC. The casing is available in a screw slot version, or for mounting in a 19" rack mount casing.

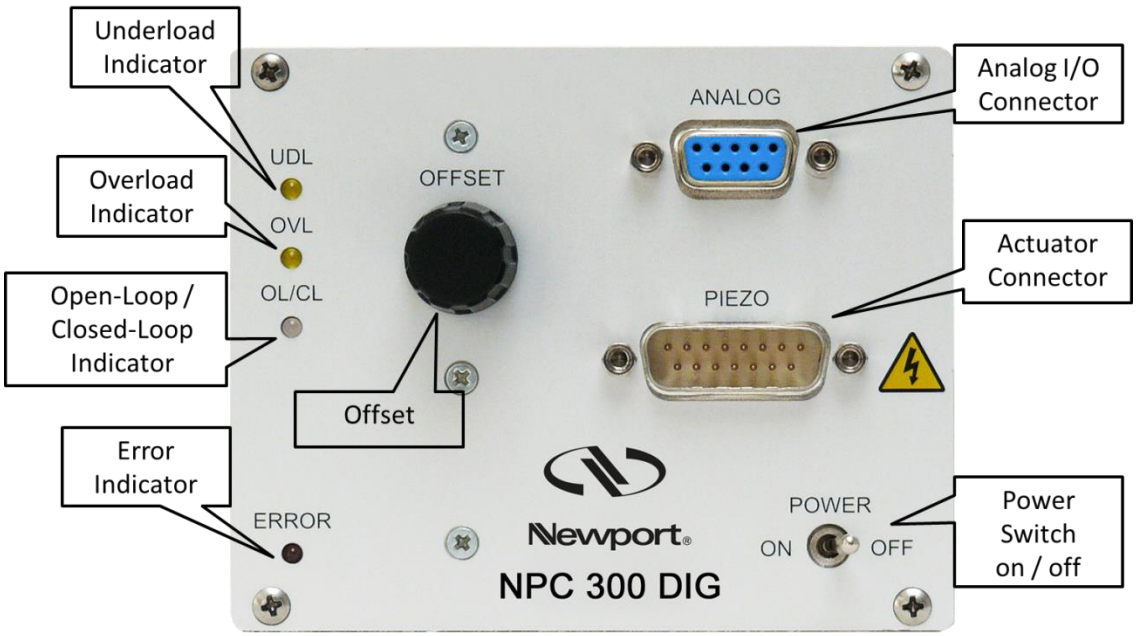
Piezo actuators can be controlled in three different ways, either by using the encoder knob on the front panel, by analog signal ranging from 0 to +10V, or by PC-Interface RS232. The best results for resolution and accuracy can only be achieved by setting the digital target values. The high performance of the ***NPCxxxDIG*** with 20bit effective resolution guarantees the customer high speed positioning, with the highest accuracy available. It includes rise time optimization and an active oscillation damping for every special application.

The ***NPCxxxDIG*** comes with an auto calibration routine and automatic sensor identification (ASI). All values of the actuating system, like capacitance, measurement system, resonant frequency, and motion, are automatically stored in the amplifier. An automatic amplifier optimization occurs after actuator identification. All this makes our system configuration very easy and saves our customers a lot of time.

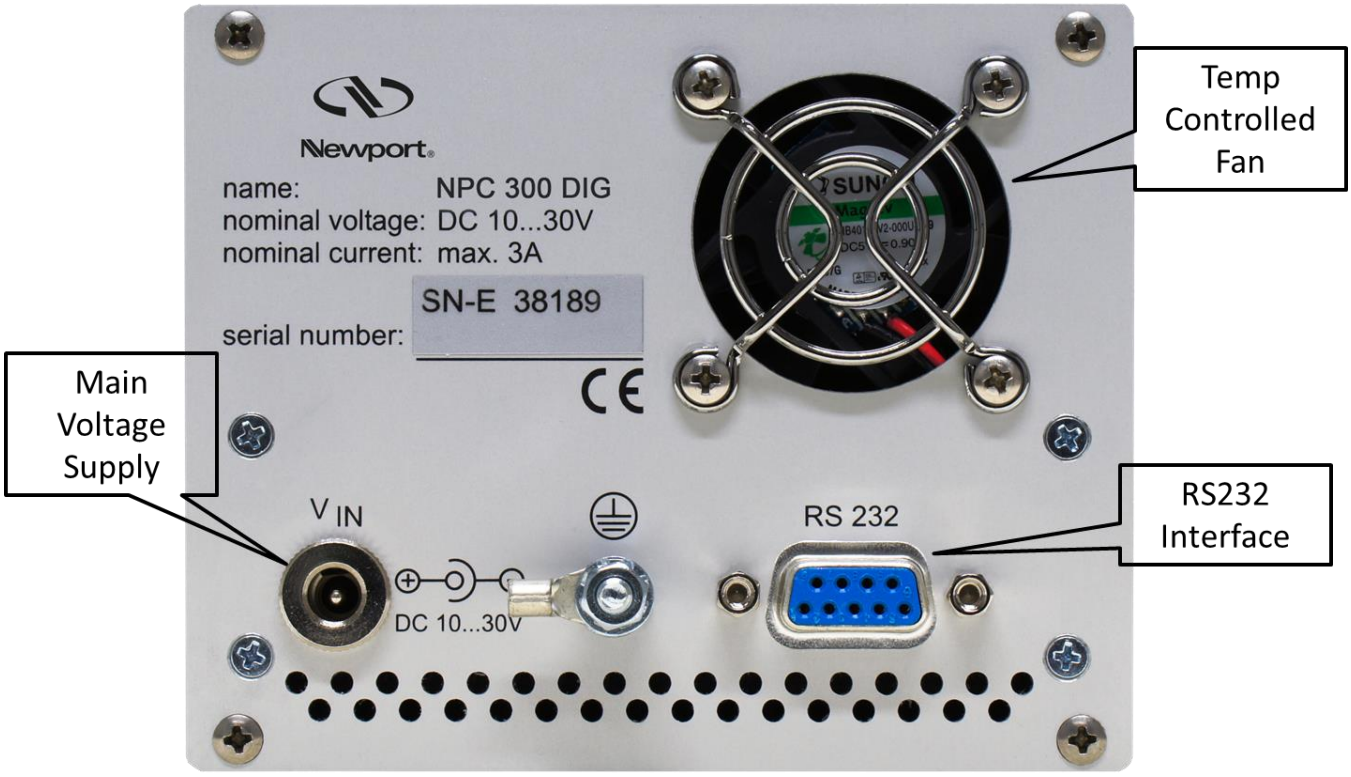
A unique feature of the ***NPCxxxDIG*** is that it can be used in combination with strain gauge or capacitive feedback sensors without additional modification. The DSP (digital signal processor) runs at 64 MHz, and at a sampling rate of only 20 µsec. We have also implemented adjustable features such as slew rate, notch filter, and pass filters. A built-in function generator offers sine, triangular, and square functions, as well as noise and sweep.
All operating elements are usable from the front side. The PC-interface on the back side allows wiring in switch cabinets. Extension cables for great distances are available.

8.2 User Elements / Connections

8.2.1 Front panel

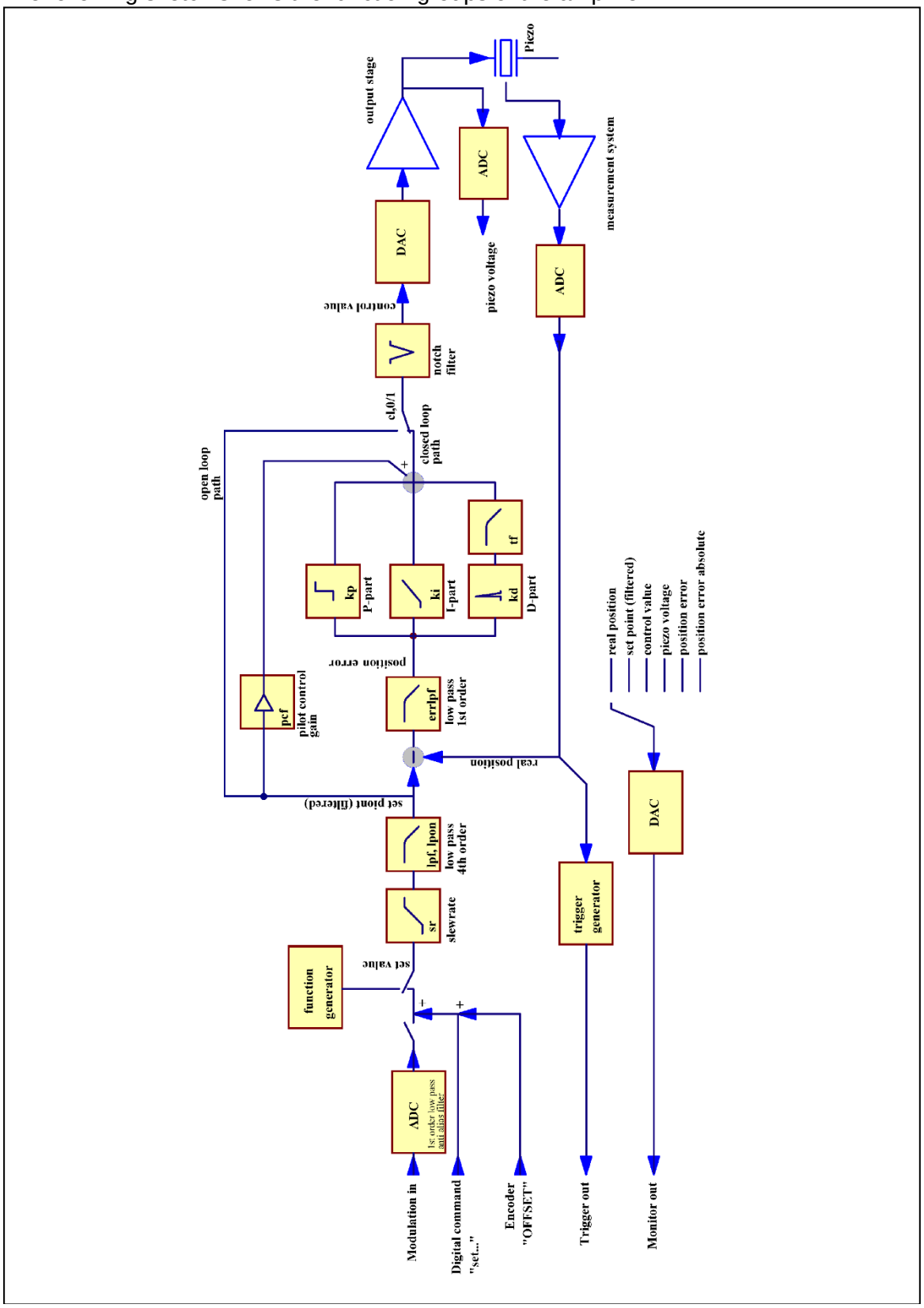


8.2.2 Back Panel



8.3 Function

The following sketch shows the function groups of the amplifier:



sketch 1: function groups of the amplifier

The command for the controller consists of the analog signal applied to the MOD input, the digital value given by the encoder “OFFSET” and the digital value from the RS232 interface. The slew rate of the amplifier can be adapted to your system using the "slew rate" limiter or the 4th order low pass filter, i.e. frequencies, which might stimulate resonances, can be suppressed before they interfere with the closed loop. The slew rate of this set value is adjustable.

The PID-controller calculates the difference (err) between this input (com) and the value from the measurement system (mes).

err = com – mes	com = command mes = position signal

The proportional term (kp) amplifies the control deviation without reducing frequency and drives the controller until the difference between the sensed motion and the command:

yp = kp * err	kp = adjustable gain yp = output of p-term

The P-controller can’t eliminate the error completely, because it needs a deviation to drive. To minimize the permanent offset of the P-term an integral action (I-term) is required. Ts is the time constant governing the time it takes for the output to get a certain value. For a step input it is the time taken for the output to equal the input.

yi = yi + ki * err * Ts	Ts = 1 / sample frequency (50 kHz) 1/ki = time constant yi = output of i-term

In general, the differential term combats oscillation (it adds damping) and increases the reaction speed of the PI–controller:

yd = kd * 1/Ts * (err – err[n-1])	err[n-1] = control deviation previous sample kd = differential time constant yd = output of d-term

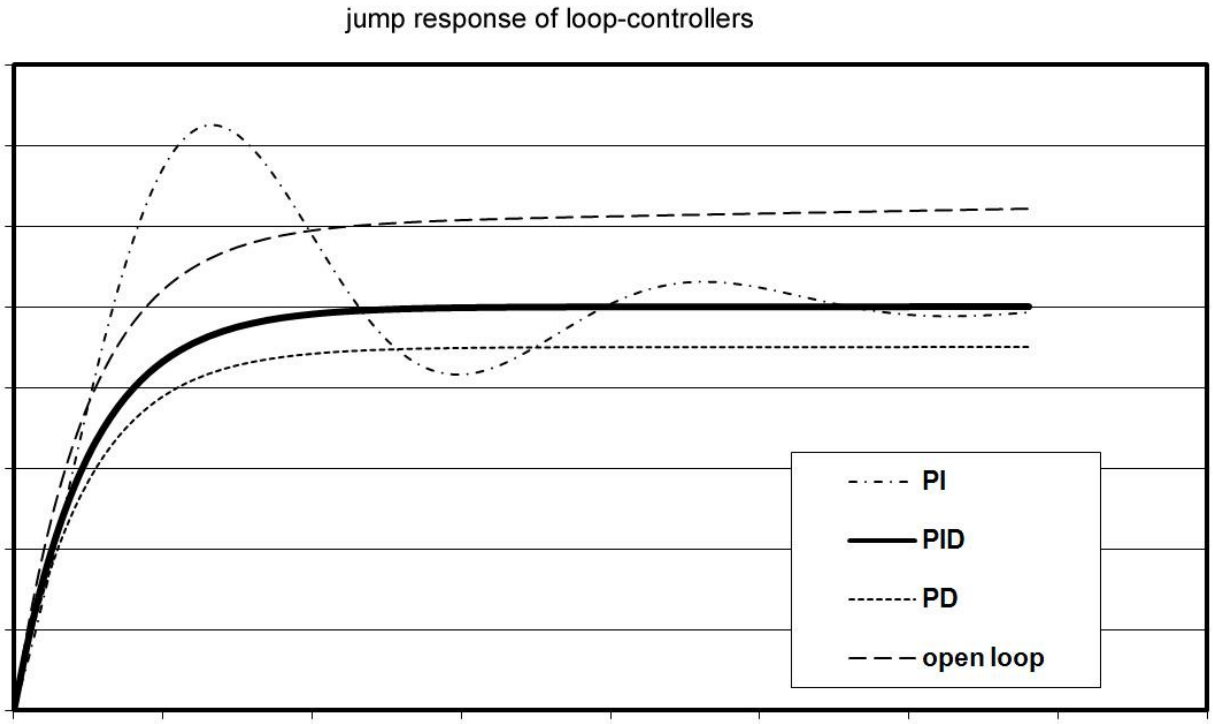
Be careful when using the d-term, because stochastic errors, like noise, cause extreme reactions. The addition of these 3 terms generates a PID–controller. The output of the controller is the set value for the power amplifier to drive the piezo actuator:

y = yp + yi + yd	y = output of PID-controller

In open loop mode, the PID-controller is bridged and the command input controls the amplifier.

Using a subsequent steep notch filter the main resonant frequency will be damped by another order of magnitude. While using open loop you can also switch on the notch filter to reduce the stimulation of the resonant frequency.
The PID-specific parameters kp, ki, and kd are stored in the actuator’s ID-chip by default. These parameters will work for most applications. Depending on your special application and load, the mechanical response can be optimized.

The following sketch describes the step response of the different terms:



sketch 2: transfer function

When using a notch filter, the main resonant frequency will be damped by an order of magnitude. While using open loop you can also switch on the notch filter to reduce stimulation of the resonant frequency. Using the notch filter might increase noise.

The PID-specific parameters kp, ki, and kd are stored in the actuator's ID-chip by default. These parameters will work for most applications. Depending on your special application and load, the mechanical response can be optimized.

8.3.1 Technical Data

	NPC50DIG	***NPC300DIG***
Input voltage:	10 – 30 VDC	
Power supply connector:	low voltage socket with 2.1mm-pin	
Input current:	max. 2.5A @ 10V max. 1.0A @ 30V	max. 5.5A @ 10V max. 2.5A @ 30V
Power consumption:	max. 30W	max. 55W
Output power:	7.5W (max. 15W for nanoX™ actuators)	max. 45W
Output voltages:	-20V...+130V +130V...-20V for nanoX™ actuators	
Output current (constant current):	50mA permanently (2x 50mA for nanoX™ actuators)	300mA permanently (2x 150mA for nanoX™ actuators)
Output noise:	<0.3mV$_{RMS}$ @ 500Hz	
Actuator / measurement connector „PIEZO“:	15pin D-Sub plug	
Monitor output:	0...+10V (programmable signal source)	
Monitor output impedance:	1kΩ	
Modulation input:	0...+10V (disconnectable)	
Modulation input impedance:	25kΩ	
Trigger output (low-active)	5V/0V with pull-up-drain resistor 240Ω	
MOD - MON connector „ANALOG“:	9pin D-Sub socket	
Offset voltage:	-20V...+130V via encoder	
Safety functions:	short circuit proof, temperature fuse	
Display (LED):	green / yellow green = in operation / open loop yellow = closed loop OVL (yellow) = overload UDL (yellow) = underload	
Interface	RS232	
Interface connector	9pin D-Sub socket	
Cooling	Fan, temperature controlled	
Dimensions (W H D):	(130 x 86 x 230) mm	
Weight:	3.8 lbs	4 lbs

table 1: technical data

8.3.2 MOD/MON

modulation input: MOD

The motion of the actuator can be remotely controlled using this input. The control signal must range between 0V and +10V. There is an internal addition of the MOD signal, the adjusted encoder "OFFSET", and the present digital value. To prevent external signals from influencing any parameter, please switch off the analog modulation input when it's not used (*modon, x,* 0 see 8.4.2). In function generator mode, the modulation input is permanently switched off.

monitor output: MON

With a special command many different signals can be shown. The voltage range between 0 and +10 V is available at this socket and can be monitored by using an oscilloscope. Pay attention to the inner resistance of the monitor output.

command	description	value
monsrc,<value>	monitor output (default = 0)	0 = position value in closed loop 1 = reference input 2 = PID-command voltage 3 = closed loop deviation incl. sign 4 = closed loop deviation absolute 5 = actuator voltage 6 = position value in open loop

table 2: monitor

0) position voltage in closed loop, it means an actuator with 80 µm in closed loop generates 0...+10V (= 8 µm/V or 0.125 V/µm)

1) the reference input, sum of the analog signal applied to the MOD input, the digital value by the encoder "OFFSET".

2) output of the controller, set value for the power amplifier

3) closed loop control deviation including sign: the value can be positive or negative:

Uerr = Ucom – Umes Ucom = 0...+10V
Umes = 0...+10V
Uerr = -10V...+10V

To generate an output of 0...+10V the control deviation is divided by 2 and +5 V is added. To calculate the control deviation back from the measured monitor voltage, take the following formula:

Uerr = (Umon – 5V) * 2 Uerr = -10V...+10V
Umon = 0...+10V

If the controller is properly adjusted the value is +5 V.

4) absolute closed loop control deviation:

|Uerr| = Ucom – Umes |Uerr| = 0...+10V

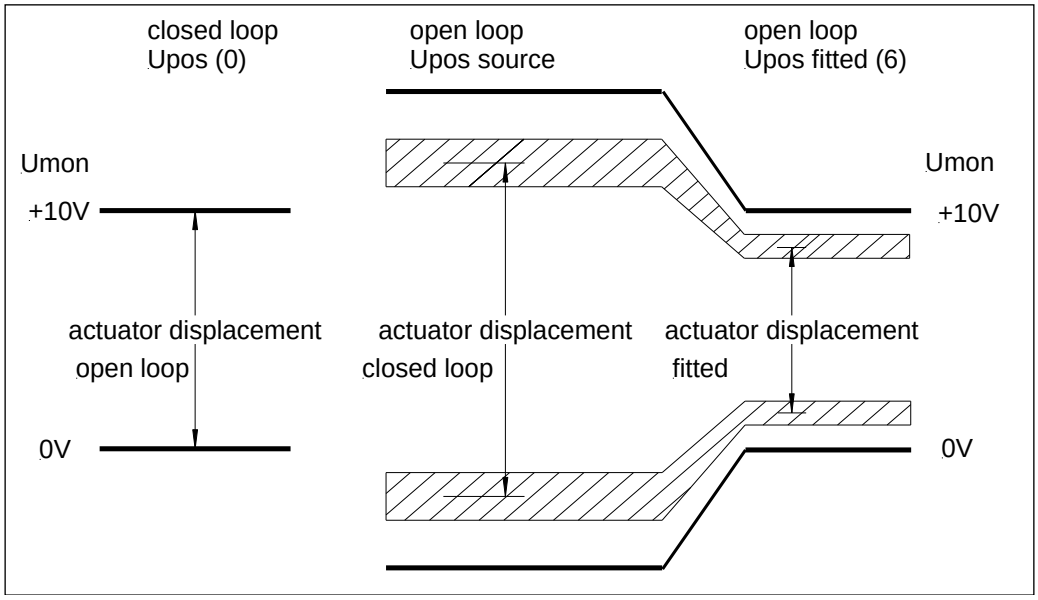
5) the actuator voltage -20V...+130V converts to 0...+10V; to calculate the actuator voltage back from the measured monitor voltage, take the following formula:

Uactuator = (Umon * 15) – 20V

6) The position voltage in open loop (OL) is greater than in closed loop. The monitor voltage would be smaller than 0V and greater than +10V. The value gets adjusted. To calculate the open loop position voltage back from the measured monitor voltage, use the following formula:

Umes(OL) = (Umon – 2.5V) * 2

The default setting is the position value in closed loop (see No. 0).



sketch 3: monitor output

8.3.3 Pinning

ANALOG: socket 9pin D-Sub

pin	designation	description
1	MON+	monitor output 0...+10V
2	MON-	signal ground
4	MOD+	modulation input 0...+10V
5	MOD-	signal ground
7	TRG+	trigger output (low-active)
8	TRG-	digital ground trigger

table 3: pinning

PIEZO: plug 15pin SUB-D

pin	designation	description
1,2,11	AGND	analog ground
3	+15V *	operating voltage measurement +15V
4,14	GND	digital ground
5	SDA	I²C-Bus SDA
6	5Veeprom *	operating voltage ID-Chip
7	Vout2	actuator voltage 2 +130...-20V for nanoX$_{TM}$
8	Vout	actuator voltage -20...+130V
9	+MESS	position signal -8...+8V
10	-15V *	operating voltage measurement -15V
12	SCL	I²C-Bus SCL
13	DETECT	actuator detection
15	Piezomasse	actuator ground

[*] Not for external use

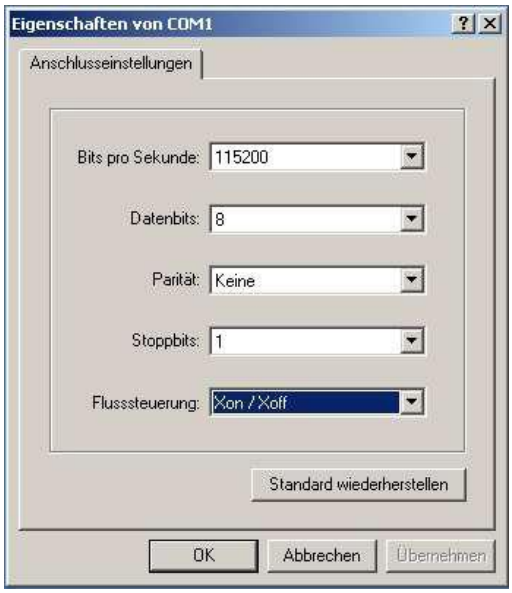
table 4: pinning

The actuator is connected to this plug. The actuator voltage goes to the piezo, the position signal from the measurement system goes to the DSP, and the integrated actuator information is stored on an ID-chip which goes to the main controller. It is important that the locking screws are screwed into the front panel.

8.4 Communication & Commands

8.4.1 Communication via RS232

The ***NPCxxxDIG*** can easily communicate with your PC with the use of a terminal program such as hypertrm.exe (please refer to the manual of your operating system). A serial connection cable (included) is required to connect to your computer. The properties of the COM port are: 115200 baud, 8 bit, no parity, 1 stop bit, software handshake (XON / XOFF).



8.4.2 Commands

global commands: <command> *Enter*

command	description
dprpon	switch on the cyclic output of the current actuator position value *[1]
dprpof	switch off the cyclic output of the current actuator position value
dprson	switch on the automatic output of the status register when status of amplifier is changed
dprsof	switch off the automatic output of the status register when status of amplifier is changed

table 5: commands

commands without values: <command> *Enter*

command	description
s	shows all available commands
stat	request content of status register (see status register)
mess	position value request [µm or mrad] *[1]
ktemp	amplifier temperature value [degree Celsius]
rohm	operation time of actuator since shipping [minutes]
rgver	version number of loop-controller request

table 6: commands without values

commands with values: <command>,<value> *Enter*

command	description	value
fan	switches the fan on/off	0 = off 1 = on
setf	set the output format of measurement value (mess)	0= three decimal places 1= scientific format
setg	set the output format of all floating point values except “mess”	0= three decimal places 1= scientific format
fenable	enables the actuator soft start	0= soft start disabled 1= soft start enabled
fbreak	aborts the actuator soft start	-
set	command value: actuator voltage (ol) displacement (cl)	-20 to +130.000 [V] 0 to xxx.xxx [µm] (maximum actuator displacement, see datasheet)
sr	slew rate	0.0000002 to 500.0 [V/ms], attributed to the modulation voltage (0 to +10V)
modon	modulation input MOD plug	0 = off 1 = on
monsrc	monitor output	0 = position in closed loop

	(0 = default)	1 = command value 2 = controller output voltage 3 = closed loop deviation incl. sign 4 = absolute closed loop deviation 5 = actuator voltage 6 = position in open loop
cl	open loop / closed loop	0 = open loop 1 = closed loop
kp	proportional term	0 to 999.0
ki	integral term	0 to 999.0
kd	differential term	0 to 999.0
sstd	set default factory settings	------
notchon	notch filter	0 = off 1 = on
notchf	notch filter frequency	0 to 20000 [Hz]
notchb	bandwidth (-3dB)	0 to 20000 (max. 2 * notch_fr) [Hz]
Ipon	low pass filter	0 = off 1 = on
Ipf	low pass cut frequency	1 to 20000 [Hz]
gfkt	internal function generator (see table 12)	0 = off 1 = sine 2 = triangle 3 = rectangle 4 = noise 5 = sweep
gasin	generator amplitude sine	0 to 100 [%]
gosin	amplitude offset sine	0 to 100 [%]
gfsin	generator frequency sine	0.1 to 9999.9 [Hz]
gatri	generator amplitude triangle	0 to 100 [%]
gotri	amplitude offset triangle	0 to 100 [%]
gftri	generator frequency triangle	0.1 to 9999.9 [Hz]
gstri	symmetry of triangle	0.1 to 99.9 [%] default = 50 %
garec	generator amplitude rect.	0 to 100 [%]
gorec	amplitude offset rectangle	0 to 100 [%]
gfrec	generator frequency rectangle	0.1 to 9999.9 [Hz]
gsrec	symmetry of rectangle	0.1 to 99.9 [%] default = 50 %
ganoi	generator amplitude noise	0 to 100 [%]
gonoi	amplitude offset noise	0 to 100 [%]
gaswe	generator amplitude sweep	0 to 100 [%]
goswe	amplitude offset sweep	0 to 100 [%]
gtswe	generator sweep time	0.4 to 800 [sec/decade]
sct	scan type	0 = scan function off 1 = sine scan (one period) 2 = triangle scan (one period) 3 = sine scan (two periods) 4 = triangle scan (two periods)
ss	start scan	without value: request scan state

		1 = starts scan
trgss	trigger generation stroke position start	minimum: >0.2% of total stoke to maximum: total stroke minus 0.2% of total stroke [µm] or [mrad]
trgse	trigger generation stroke position end	minimum: >0.2% of total stoke to maximum: total stroke minus 0.2% of total stroke [µm] or [mrad], always keep: trgse > trgss !
trgsi	trigger generation position intervals	>0.05% of total stroke in closed loop [µm] or [mrad]
trglen	duration of trigger impulses	n * 20µs n=1...255
trgedge	trigger generation edge	0= trigger generation off 1= trigger generation at rising edge 2= trigger generation falling edge 3= trigger generation at both edges

table 7: commands with values

Note *[1]: The controller cyclically transfers the newly measured value to the signal buffer of the interface every 500 milliseconds. This value can then be read out via the interface. Subsequent increasing of the query sequence for this value does not increase the refreshing rate. If the piezoelectric actuator moves with higher frequencies, aliasing occurs. In this case the displayed values no longer correspond with the actual motion value!

Example:
An actuator with 80µm displacement in closed loop should take a swing in rectangle mode from 20µm to 50µm. It should stay 50ms on 20µm and 150ms on 50µm. The reaction of the measurement system is connected to the monitor output.
commands:
- cl,1 *Enter* switch on closed loop
- gfkt,3 *Enter* generator function rectangle
- gfrec,5 *Enter* frequency rectangle = 1 / (50ms + 150ms) = 5Hz
- garec,37.5 *Enter* amplitude rectangle = (50µm – 20µm) / 80µm * 100% = 37.5%
- gorec,25 *Enter* offset rectangle = 20µm / 80µm * 100% = 25%
- gsrec,25 *Enter* symmetry rectangle = 50ms / (50ms + 150ms) * 100% = 25%
- monsrc,0 *Enter* set monitor source to position value in closed loop

8.4.3 Status Register

The status register is a 16bit register, in which each bit describes different properties of the amplifier or actuator. The decimal sum of all bits is the value of the status register:

bit	binary	description	decimal
0	2^0	0 – actuator not plugged 1 – actuator plugged	0 1
2,1	2^2, 2^1	0, 0 – actuator without measuring system 0, 1 – strain gauge measuring system 1, 0 – capacitive measuring system	0 2 4
3	2^3	------	--
4	2^4	0 – closed loop system 1 – open loop system	0 16
5	2^5	------	--
6	2^6	0 – piezo voltage not enabled 1 – piezo voltage enabled	0 64
7	2^7	0 – open loop 1 – closed loop	0 128
8	2^8	------	--
11,10,9	2^{11}, 2^{10}, 2^9	0, 0, 0 – generator off 0, 0, 1 – sine on 0, 1, 0 – triangle on 0, 1, 1 – rectangle on 1, 0, 0 – noise on 1, 0, 1 – sweep on	0 512 1024 1536 2048 2560
12	2^{12}	0 – notch filter off 1 – notch filter on	0 4096
13	2^{13}	0 – low pass filter off 1 – low pass filter on	0 8192
14	2^{14}	------	--
15	2^{15}	0 – fan off 1 – fan on	0 32768

table 8: status register

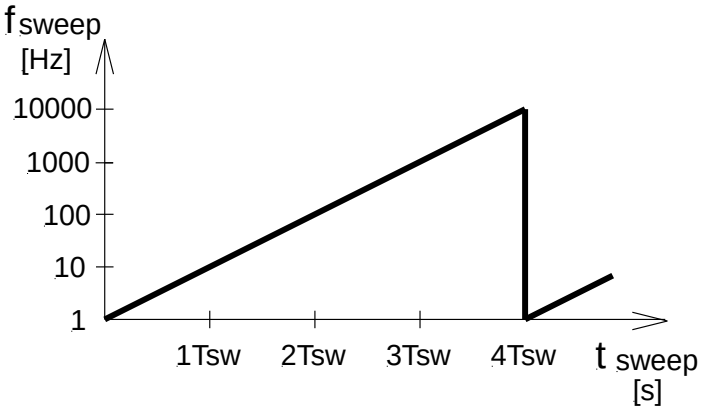
8.5 Function Generator

The ***NPCxxxDIG*** amplifier contains its own function generator, which is capable of performing multiple functions. The function generator can be programmed by using the commands mentioned above. The following functions can be executed:

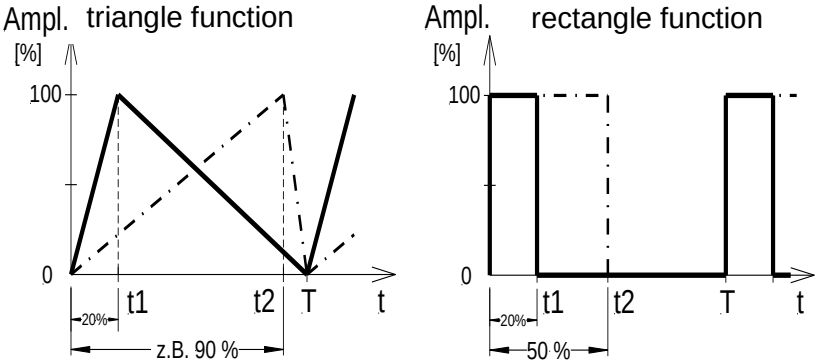
function type 0 = off	Sine 1	Triangle 2	Rectangle 3	Noise 4	Sweep 5
amplitude 0 to 100%	√	√	√	√	√
offset 0 to 100%	√	√	√	√	√
frequency 0.1 to 9999.9Hz	√	√	√	-	-
sweep time 0.4 to 800sec/dec	-	-	-	-	√
duty cycle 0.1 to 99.9%	-	√	√	-	-

table 9: functions and their parameters

The amplitude that has been selected is the peak to peak value. The sweep depth is fixed by 1Hz to 10kHz (4 decades). In the meantime, the frequency increases logarithmically.This case represents the "sweep" parameter of the increasing frequency per decade.



The symmetry of a signal describes, in the case of the triangular function, the ratio of rise time t to time period T.
Based on this, a variation can be introduced between a fast increase and a slow decrease as well as a slow increase and a fast decrease of the function. By using the rectangular function, the duty cycle of high signal in relation to time of a period is described.



Caution: Do not activate the trigger function in sweep mode (trgedge = 0).

8.6 Output of Trigger Signals

Using trigger signals allows us to get an electrical signal when a position is reached or crossed. The trigger points refer to the measured value (stroke or tilt). The trigger is low-active, i.e. a high/low edge shows that you have reached a trigger point.
The active stroke/tilt-range for trigger generation is given by “trgss” (start (lower) position) and “trgse” (end (upper) position). The interval between the trigger points is given by “trgsi”. It is possible to get trigger signals at the rising edge (trgedge,1), the falling edge (trgedge,2) or both edges (trgedge,3).
To disable the trigger generation set trgedge,0. The measurement unit for trgss, trgse, trgsi is the actuator specific unit (e.g. µm or mrad), the length of a trigger signal can be set to multiples of 20µs (standard is 1 * 20µs).
Take care that is there no overlap between two trigger impulses. In this case, you must minimize the length of the impulses (trglen,1) or decrease the movement speed of the actuator.
Furthermore, you must be sure that the trigger range (between trgss and trgse) passes through plus 0.2% of the total stroke, otherwise no trigger will be generated because no change between rising and falling edge will be detected.

Caution: Do not activate the trigger function in sweep mode.

Example (trgedge = 1...3):

An actuator with a closed loop stroke of 80µm is used as follows: rising edge (***trgedge,1***), start point 10µm (***trgss,10***) end point (***trgse,30***) and interval 5µm (***trgsi,5***), i.e. trigger points are at 10, 15, 20, 25, 30µm. After reaching position 10µm (from a lower position; rising edge!) the trigger is set and the next trigger point will be calculated (15µm), the trigger output will be reset after n * 20µs (***trglen,***n) and the trigger function is waiting to reach the next trigger position (15µm) and so on. After reaching the 30µm position, the next Trigger position is set to 10µm, the trigger impulse will be generated when the 10µm position is reached from a lower position than 10µm (rising edge).

Extended trigger functions (trgedge = 4 / 5 / 7):

The function trgedge,4 triggers at any change of moving direction, with trgedge,5 the output is inverted to trgdge,4. No parameters will be needed.

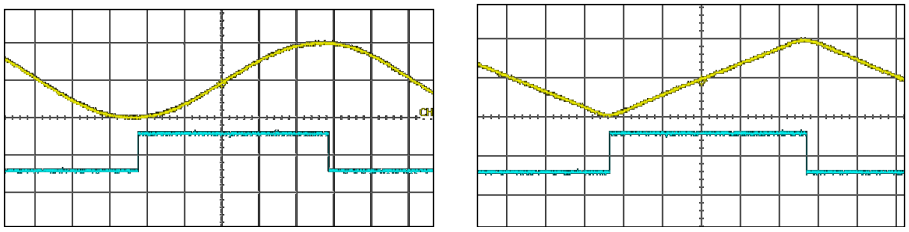


Abb: trgedge,4

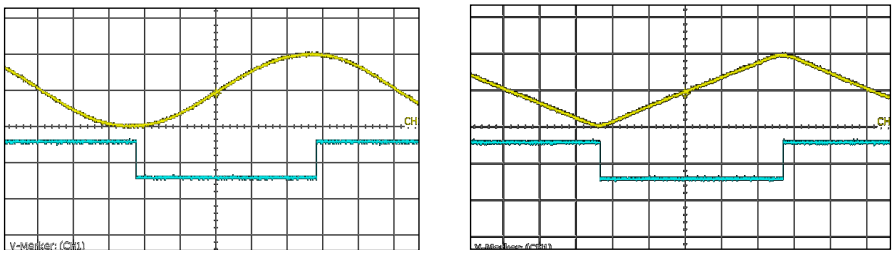
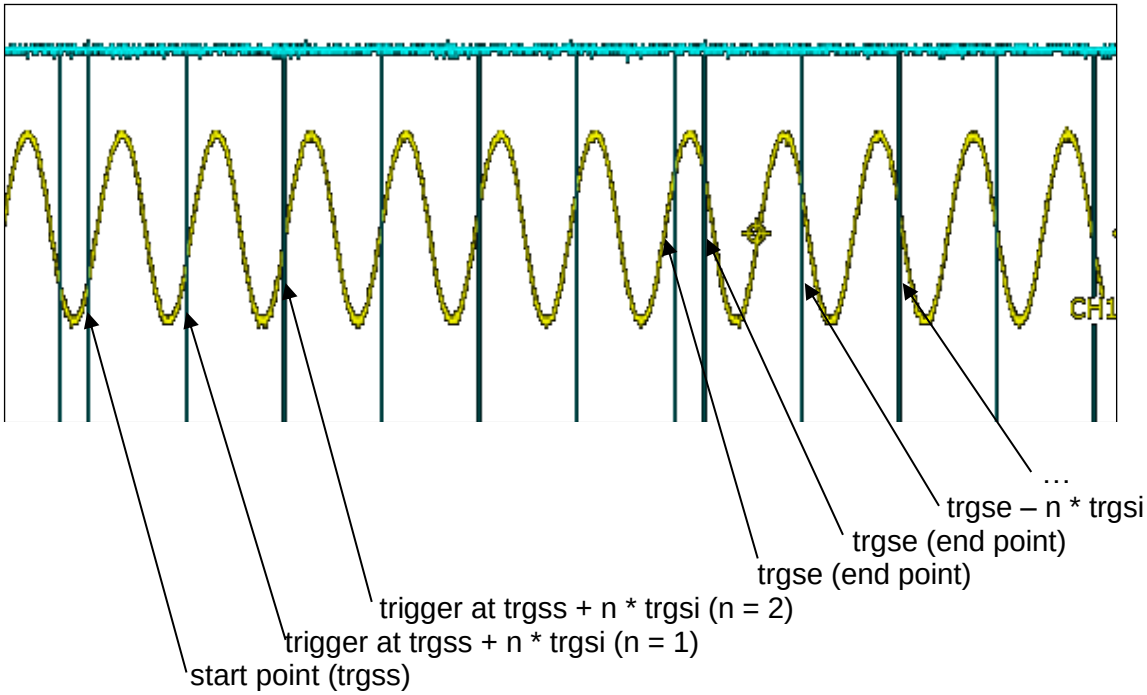


Abb: trgedge,5

Function trgedge,7: at any change of moving direction a trigger with length n * 20µs appears (parameter n: trglen).

Trigger function „moving trigger“ (trgedge,6)

This function is parameterized by trgss, trgse, trgsi und trglen. On each period, only one trigger appears, the trigger point “moves” at every period by its increment (trgsi). After reaching the end position (trgse) the trigger point “moves” backward.



The recognition of edges works as follows:
During the rising edge, the highest measurement value (position) will be stored. If there is a decrease in the measurement value of more than 0.2% (of total stroke) under the stored value, a falling edge will be recognized. During the falling edge, the lowest measurement value (position) will be stored.
If there is an increase in the measurement value of more than 0.2% (of total stroke) over the stored value, a rising edge will be recognized.
This principle depends on whether or not trgss and trgse are bordered by a working area that crosses at least 0.2% (of total stroke) out of the borders.

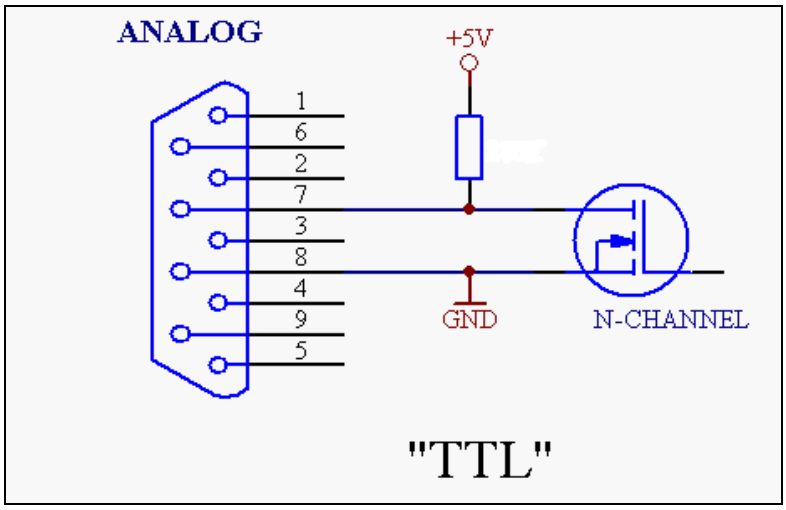
trgss	**lower trigger position** this is the lowest value where a trigger signal is generated	unit µm or mrad
trgse	**upper trigger position** this is the highest value where a trigger signal is generated	unit µm or mrad
trgsi	**trigger interval** this is the distance between the trigger points	unit µm or mrad
trgedge	**trigger edge** this value depends on which direction the trigger point must be reached for trigger generation	0: trigger disabled 1: trigger at rising edge 2: trigger at falling edge 3: trigger at both edges
trglen	**trigger length** this values depends on the duration of a trigger impulse	(n * 20µs n = 1…255)

table 10: commands for trigger generation

Hardware:

The output for trigger signals is the 9-pin D-Sub connector “ANALOG”.

The pin 7 (trigger out) and pin 8 (ground) are used.



sketch 4: internal circuit

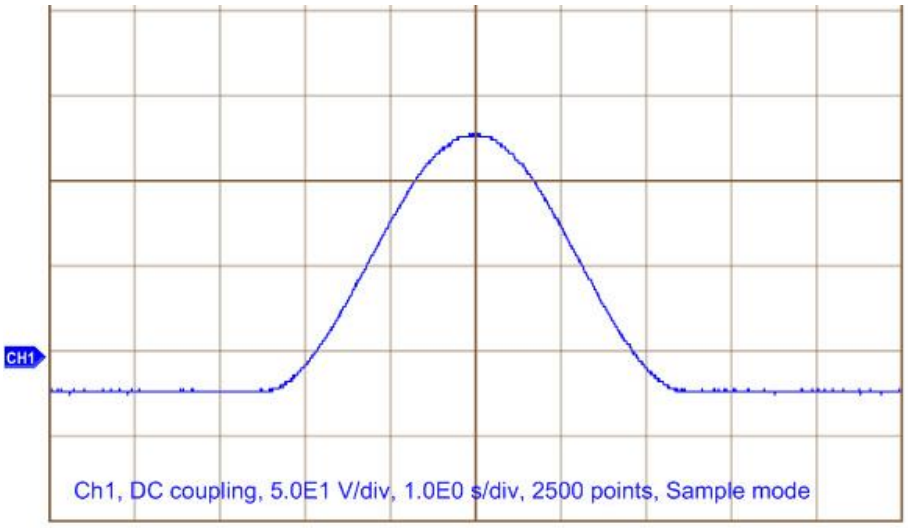
8.7 Scan Function

The scan allows the output of exactly one period of the function generator (sine or triangle). This will require that the relevant functional parameters be set (frequency, amplitude, offset, or symmetry). The function generator does not need to be activated (gfkt,0). To select a scan, set the scan type to sine (sct,1) or triangle (sct,2).
The scan starts with “ss,1”. During a scan, the status can be requested with "ss<CR>". The answer “ss,2” means the scan is still running, “ss,0” indicates the scan is complete. A running scan can be aborted by setting the status to zero (ss,0<CR>).

Example:

scan sine , 100% amplitude, 0% offset, frequency = 0,2Hz

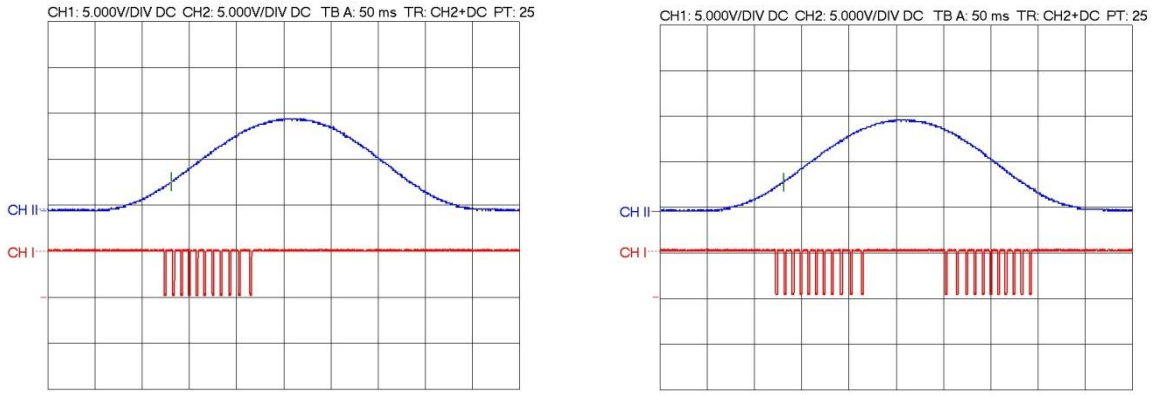
gfsin,0.2<CR>
gasin,100<CR>
gosin,0<CR>
scan type: sct,1
start scan: ss,1



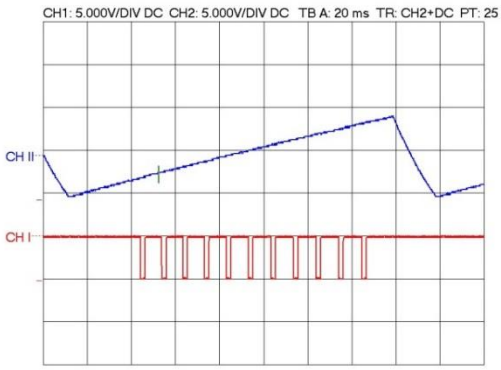
sketch 5: output voltage of a sine scan (open loop)

Application:

The combined use of trigger generation and scan function permits a highly exact scan of a probe. Acceleration forces (and with it oscillations) are minimized by using a sine function, and actions can be initiated by the trigger generation at exactly defined actuator positions.



sketch 6: sine scan with trigger impulses at rising / both edges

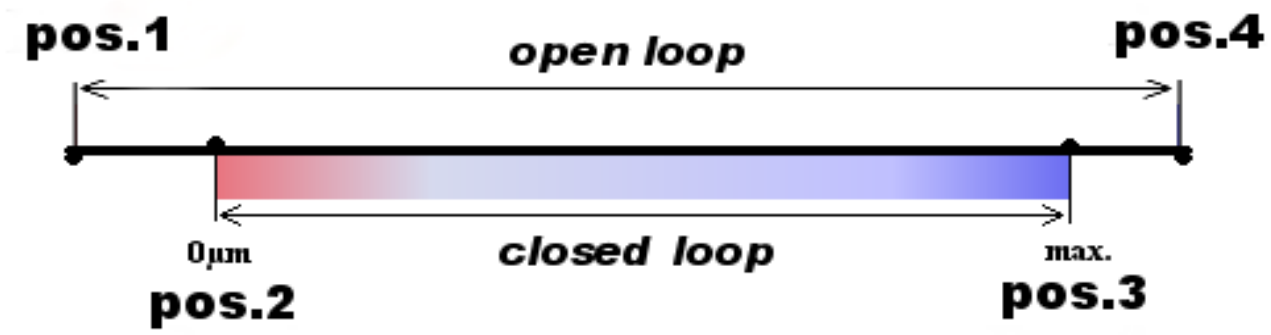


sketch 7: triangle scan with trigger impulses at the rising edge

9 Handling

The actuator is connected to the ***NPCxxxDIG*** using the “PIEZO” plug. The encoder knob is used to adjust a static output voltage or position, depending on the operation mode (Offset). The “ANALOG” plug offers analog interface to control the amplifier using a voltage between 0 and +10 V. So, arbitrary and scan functions are possible. Please remove any analog input voltage from the amplifier before you turn the system on or off to avoid damage. To control the amplifier via RS232 please connect the computer and the amplifier with the provided serial cable. Then start the terminal program (see chapter *communication*).

After power-on, the LED's “UDL“, and “OVL“ blink. The amplifier makes its power-on self test for 2 seconds. During this procedure all necessary parameters are transferred from the actuators ID-chip to the amplifier. When the “UDL“ and “OVL“ LEDs stop blinking, the amplifier has initialized successfully. Amplifiers without an attached actuator cannot complete this sequence.
When the system starts up and no external voltage is applied to the MOD input, the actuator is in the most negative position (pos.1) of its deviation (pos.1 to pos.4, see sketch 2). By pressing the knob in, the operation mode changes to closed loop and the “OL/CL” LED changes to yellow. When closed loop is turned on, the actuator moves to the start position of the closed loop range (pos.2). Turning the encoder to the right will increase the deviation until it reaches its maximum position (pos.3). This range will vary depending on your type of actuator.



sketch 8: open loop / closed loop

The yellow “OVL” LED shows an overload, the yellow “UDL” LED shows an underload. Please try to avoid this. When an external analog voltage is applied, try to decrease or remove it. If the LED's still light up, check the connection between the amplifier and the actuator. Additionally, a mechanical blocking or overload of the actuator can prevent actuators from reaching their position. If none of the described troubleshooting has worked, turn off the system and contact our support team. Please do not continue working after your actuator has been damaged.

The values of calibration are valid only for a specified assembly configuration. Any change in the assembly configuration can cause the modes OVL or UDL. Please provide us with your assembly configuration in advance.

10 Controller Adjustment

When any actuator made by ***Newport Corporation*** is connected to the ***NPCxxxDIG***, amplifier their specific values are read from the actuator's ID-chip. The Digital Signal Processor (DSP) of the amplifier is set with these values. These parameters were investigated in the ***Newport Corporation*** laboratory and ensure safe function of the actuator.

There are no kp-, ki-, and kd-values for actuators without a measurement system because the closed loop mode is impossible in this configuration. Closed loop is automatically switched off.

To adapt the controller properties to your special application please start with the default values. At first please switch on the closed loop mode by pressing the encoder knob "OFFSET" or by the command ***cl,1*** via RS232. Change one parameter step by step and check the result with the oscilloscope on the ANALOG 9pin SUB-D socket of the amplifier. You must install a monitoring output to *position value in open loop* with the command ***monsrc,6***.

In general, change the parameters in small steps and, depending on the actuator's reaction, slightly increase the step width. If the system begins to oscillate, switch off the closed loop immediately by pressing the encoder knob, then reset the last values entered!

First of all, check the function of the notch filter. This has been factory adjusted so that the main resonant frequency is suppressed in an actuator with standard mass loading. If your application has a different mass, the resonant frequency changes (higher mass = lower frequency). The notch parameters are adjustable with the commands ***notchon***, ***notchf*** and ***notchb*.**

The sweep function of the internal function generator can be used to determine the resonant frequency. Use **function generator** in the **menu** of the actuator. Set the amplitude to 5%, the offset to 0%, and the sweep time to 1 (1sec/decade). Set the amplifier to open loop ("OL/CL" LED lights green). With the MOD/MON cable (MON plug) you can connect the oscilloscope to the ANALOG socket of the amplifier. The following adjustments on the oscilloscope are required: store function, time base = 0.5 sec/div and input voltage = 0.1V/div. The display shows the response of the actuator measured by the integrated measurement system. Before the measured curve swings out, there is a position where the amplitude is 0 Volts. This is the adjusted notch frequency. At the resonant frequency, the measured curve goes very high. At this point you have to adjust the notch frequency to the resonant frequency to linearize the curve. Using the notch filter might increase noise.

The correct ki-value is determined as follows:
In the **function generator** menu, set rectangle to 1 Hz, amplitude to about 50%, and offset to 25%. Please set the monitoring output to **Umes/CL** in the **analog i/o** menu. The following adjustments on the oscilloscope are required: store function, time base = 0.05sec/div and input voltage = 1V/div. Set the amplifier to closed loop ("OL/CL" LED lights yellow). The oscilloscope display shows the step response of the actuator measured by the integrated measurement system. If the slew rate is too low, please increase the ki-value in the **digital controller** menu. The over swing after the rise time should be smaller than 1% of the total step.

In these adjustments, the actuator system can begin to oscillate in resonant frequency. Please switch off the closed loop immediately by pressing the encoder knob "OFFSET". Then reset the last values entered! Continuous use at resonance can damage the actuator!

Now you can try to increase the slew rate in **slew rate/filter** menu**,** as long as no oscillation or large over swing occurs.

11 Troubleshooting

Please check all cables and connections first if the system is not working properly.

error	**possible solution**
UDL/OVL-LED blinks	Check the connection between actuator and amplifier. Check the actuator cable for damage.
UDL/OVL-LED light up in closed loop mode	The actuator is not able to reach the commanded position. Check the modulation input and offset. Check your actuator for mechanical blocking. Check whether your actuators move properly in open loop mode.
actuator oscillates in resonant frequency in closed loop	Check the PID-controller adjustments, reduce the ki-value, Reduce the kd-value. Check whether the function generator is still working.
read back parameters always deviate at the same level from the digital target value	Please switch off the analog modulation input when it's not used. Command: *modon,0* (see 8.4.2 commands). External signals can cause an interference or a command value offset.
actuator does not move in spite of the applied analog modulation signal on the MOD input	Please switch on the analog modulation input by using command *modon,1* (see 8.4.2 commands).
interface output values do not correspond to the applied signal value	Aliasing: If the signal read out sequence is lower than half of the working frequency only the serial data is affected. The real motion values are not affected.

table 11: errors

11.1 Error Register

The error register is a 16bit register. Each bit describes different error. Once error has occurred the error register changes and error message as a decimal number will be issued via interface.

„**?ERR,error**“ CR LF.

The decimal sum of all bits results the error value:

bit	description		decimal
0	I²C error	0 – no error 1 – I²C error	0 1
1		------	--
2	temperature	0 – no error 1 – temperature out of range	0 4
3	OVL	0 – no error 1 – overload in CL	0 8
4	UDL	0 – no error 1 – underload in CL	0 16
5 – 15		------	--

table 1: error register

For high precision positioning in nm-resolution you must warm up the amplifier 2 hours before use. A constant temperature is beneficial. Consider that a variation of 5 Kelvin results in elongation by 13µm in steel with a length of 200mm. The best results for resolution and accuracy can only be achieved by setting the digital target values. Therefore, please switch off the analog modulation input when it’s not used.

The equipment customization makes adaptations according to customer preferences that are possible in terms of the technical threshold values e.g. the main voltage or the output voltage. Please contact our technical service department in order to find out the possibilities for your specific application. Special adaptations must be paid for by the customer.

12 Your Notes