The Instruction Set

of the

NanoStep Controller

Nanostep smart / Nanostep desktop / Tango family

(Nanostep smart does not support all funktions)

1. Table of Contents

2. Introduction

Axes:
Nanostep / Tango controllers provide up to 4 axes. The axis specifiers used in the Nanostep / Tango instruction set are ASCII x, y, z, and a. Axes can be addressed separately by using the axis specifier or combined if no axis is specified in the instruction.

Instruction syntax:
All Nanostep / Tango controllers communicate via a standard serial COM port interface, independent of the controller type (RS232C, USB, PCI, PCI-E). The instructions and parameters are sent as cleartext ASCII strings with a terminating carriage return [CR], which is 0x0d hex. Characters may be upper-, lower- or camel-case. The parameters are separated by a space character.
This provides easy access to all functions by using a simple terminal program such as HyperTerminal. A typical instruction syntax is as follows:

[!,?][instruction][SP][optional axis] [parameter1][SP][parameter2] [etc…] [CR]

[!,?] Read/write specifier, required by most instructions:
! (exclamation mark) = to write parameter, execute an instruction etc.
? (question mark) = to read data (returns settings, or status, etc.)

[instruction]	Is the instruction word itself.
[SP]	Space (ASCII 0x20 hex) as separation.
[optional axis]	Axis character x, y, z or a if only one axis must be addressed.
[parameter]	Usually integer or floating point numbers, floating point uses decimal point, no comma.
[CR]	Termination (ASCII 0x0d hex), causes instruction execution.

A read instruction may return more than one parameter. In many cases the number of returned parameters depends on the amount of available axes:
[axis X] [if available: axis Y] [if available: axis Z] [if available: axis A]

For some instructions that return fractional numbers (e.g. ?pitch, ?gear, ?vel, ?encperiod and more) the number of returned fractional digits can be specified in order to increase resolution when reading back the value. For '?pos' and similar position returning functions (e.g. 'lim'), the number of fractional digits can be set by the '**resolution**' parameter.

Syntax examples:

!vel 10 1.5	set velocities for the first two axes
!cal	command all axes to perform a calibration move
!moa y 10.1	move y axis to absolute position 10.1
?pos	returns position of all axes (e.g. 0.0000 0.0000 0.0000)
?vel x	returns velocity setting of X axis only (e.g. 10.000)

Moves:
Move instructions are executed as a vector move. If several axes are started with one instruction they will reach their destinations at the same time. This means that - depending on velocity, acceleration and travel distance - one leading axis travels at its full velocity while the others follow synchronously. To move axes independently with their individual velocities, they have to be started separately by using single axis instructions. Please refer to the "move" instruction descriptions.

Settings:
Most settings can be stored permanently in the Nanostep / Tango Controller, so they are available from power on. When stored once, this reduces initilaization overhead of the application software. Refer to the **"save"** instruction for further information. Parameters that are saved can be identified by a 'Y' in the Save column of the **brief instruction set description** later in this document.

Character limits:
To prevent the input buffer from overflow, please do not send more than 255 characters at once.
Such may occure when sending the setup sequence to the Nanostep / Tango controller. A good practice is to request the **"?err"** state after each setup instruction. This will return the information if the parameters were accepted or not while preventing overflow.
Another solution is to activate the **"!cts"** handshake (available only with Desktop RS232C and some USB versions). This will automatically halt the PC transmission for as long as the input buffer is full. The PC COM port then must be opened with hardware handshake on, as well. Please refer to the **"!cts"** instruction description.

Important: Security speed limitation!
The Nanostep / Tango controllers have a built in security function, which reduces the maximum travel velocity to a secure 10mm/s for as long as no initial **"cal"** and **"rm"** moves have been executed. This is to saveguard the driven axis against damage that could be caused by moving fast into its end positions. After calibrating the axis into its endswitches (cal and/or rm if switches are mounted and enabled) the travel velocity is no longer limited.
If it is not wanted or impossible to do a calibration and range measure move on each power on:

A) The speed limit may be increased to up to 100mm/s at own risk. Please refer to the **"secvel"** instruction for further information.
B) The !rm can be skipped by instead using !**vrm** (please read remarks).
C) Non existend limit switches can be deactivated (swact) and then do not require a !rm. In such case secvel will be released after !cal.

Important: Measuring units!
The measuring unit is set by the **"dim"** instruction, where dim 2 [mm] is the default value.
In all dim settings, except of dim 9, the velocitiy is motor revolutions per second! Only dim 9 provides the millimeter unit for most parameters[1], positions and velocities.

Extended mode:
In addition to the improvements when using dim 9 units, there is an option to enable extended mode behavior. It enables more functionality, like separate calibration, rm and joystick velocities, which else are the same as the axis velocity (vel). Please refer to the **"extmode"** instruction for further details.

[1] Only '**calbspeed**' and '**calrefspeed**' are always in 1/100 turns/sec, even in dim mode 9

3. Hint for controller initialization

Please make sure that first of all the following parameters have to be set:

- The axis units (here called **"dim"**)
- If the controller firmware version is 1.32 or above: the **extmode**
- The axis **pitch** and – if used – also the **gear**, which are always in [mm] independent of dim

Using *dim=9* and *extmode=1* will turn all (even the vel and joyvel) units to linear axis related [mm] and [mm/s]. Extmode=1 also offers bugfixes, more features and flexibility. But it has a slightly different behavior. Please refer to the **Extended Mode** description in this document.

4. Brief Description of the Nanostep / Tango Instruction Set

Controller Informations					
Instruction		**Example**	**Save**	**Brief description**	**Page**
(?)	version	version	-	Read detailed firmware and controller version	17
(?)	det	det	-	Read the controller configuration	18
(?)	detext	detext	-	Read the controller configuration with description	18
?	readsn	?readsn	-	Read the controller serial number	19
(?)	ver	ver	-	Read default version number	19
(?)	iver	iver	-	Read further version number information	19
(?)	uptime	uptime	-	Read how long the controller is running	20
(?)	temp	temp	-	Read case temperature (avail. depends on controller type)	20
?	maxaxis	?maxaxis	-	Read number of available axes	20
?	maxcur	?maxcur	-	Show the maximum possible motor currents of all axes	20
?	etspresent	?etspresent	-	Check availability of ETS	22
?	stagesn	?stagesn	-	Read the axis serial numbers from ETS	23

Communication Interface Settings					
Instruction		**Example**	**Save**	**Brief description**	**Page**
? !	baud	!baud 9600	Y	Set RS232 baud rate to 9600 Bd (default=57600)	24
? !	cts	!cts 1	Y	Enable CTS hardware handshake	24

System Instructions					
Instruction		**Example**	**Save**	**Brief description**	**Page**
(!)	save	save	-	Save parameters to controller nonvolatile memory	25
(!)	restore	restore	-	Reload saved controller parameters from n.v. memory	25
(!)	reset	reset	-	Reset controller (forces restart, similar to cycle power)	26
!	pa	!pa 1	-	Enable power amplifiers (disable = 0), see also ‘axis’ instr.	26
? !	ipreter	!ipreter 2	Y	Select optional Venus instruction set	28

Operating Modes					
Instruction		**Example**	**Save**	**Brief description**	**Page**
? !	extmode	!extmode 1	Y	Enable extended controller behavior	29
? !	scanmode	!scanmode 1	Y	Set positioning behavior to scanmode	30
? !	scanvel	!scanvel 0.5	Y	Set scanmode vector velocity to 0.5 mm/s	30
? !	modulomode	!modulomode a 1	Y	Set positioning behavior of A axis to turntable mode 1	32

Controller States and Error Messages					
Instruction		**Example**	**Save**	**Brief description**	**Page**
? !	autostatus	!autostatus 0	-	Select autostatus response type 0 (=disabled), range: [04]	33
(?)	statusaxis	statusaxis	-	Read axis state [@,M,J,C,S,A,D,]	34
(?)	status	status	-	Read controller error state	34
(?)	err	err	-	Read error number	35
(?)	help	help	-	Read error number with additional description text	35
(?)	service	service	-	Returns a detailed parameter and state list, for debugging	35
(?)	pci	pci	-	Returns 1 if controller is plugged in a PCI slot (desktop=0)	36
(?)	isvel	?isvel x	-	Read actual velocity of the X axis	36
?	maxpos	?maxpos x	-	Read maximum available position range for X axis	36

General Adjustments

Instruction		Example	Save	Brief description	Page
? !	dim	!dim 1 1 1	Y	Set position units of X Y Z to µm	37
? !	pitch	!pitch 1 1 1	Y	Set spindle pitch of X Y Z to 1 [mm/revolution]	38
? !	gear	!gear 1 1 1	Y	Set gear factor of X Y Z to 1	38
? !	motorsteps	!motorsteps x 200	Y	Set X axis motor has 200 steps per revolution	40
? !	accel	!accel 0.1 0.1 0.1	Y	Set acceleration of X Y Z to 0.1m/s²	41
? !	accelfunc	!accelfunc 1 1 0	Y	Set acceleration function X and Y to sin², Z to linear	41
? !	stopaccel	!stopaccel 2 2	Y	Set X and Y deceleration during stop condition to 2m/s²	42
? !	vel	!vel 10 10 10	Y	Adjust speed of X Y Z to 10 [revolutions/s]	43
? !	velfac	!velfac 1 1 1	Y	Set velocity reduction factor for X Y Z to 1 (= no reduction), range is [0.01-1]	44
? !	secvel	!secvel x 20	Y	Set secure speed limit X to 20mm/s (unit is always mm/s)	44
? !	cur	!cur 0.5 0.6 1	Y	Set motor current in Ampere: X=0.5 Y=0.6 and Z=1 A	45
? !	reduction	!reduction 0.5 0.5 0.5	Y	Select 50% motor current reduction for X Y Z	46
? !	curdelay	!curdelay 1000	Y	Delay X axis motor current reduction by 1000 [ms]	46
? !	ecomove	!ecomove 30 30 0	Y	Set eco-level of X and Y to 30% current saving	47
? !	axis	!axis 1 0 -1	Y	Enable X, disable Y and switch off Z axis	48
? !	axisdir	!axisdir 0 1 0	Y	Reverse rotating direction of Y motor (caution!)	48
? !	motortable	!motortable x 2	Y	Select custom motor correction table type 2 for X axis	49
? !	usteps	!usteps 50000	Y	Set dim 0 microsteps to 50000/rev for all axes	49
? !	resolution	!resolution 6	Y	Set position return string resolution to 1 nm	50
? !	backlash	!backlash 12.3 0 0	Y	Set backlash compensation to 12.3µm in X and 0 in Y & Z	50
!?	lock	!lock 2 1	Y	Set write protection for parameter 2 (here: motor current)	51
!?	lockaxis	!lockaxis 0 0 0 0	Y	Remove lock protection from all axes (lock has no effect)	51
?	lockstate	?lockstate x	-	Read extended locked parameters, including internal limitations currently applied to X axis	52
? !	stout	!stout 2	Y	Make Status-LED state available at AUX-I/O Pin VR_OUT	52
? !	noled	!noled 1	Y	Switch Status-LED permanently off	53
? !	updelay	!updelay -5000	Y	Wait to a maximum of 5 seconds for valid external power	53

Limit Switch Instructions (Hardware and Software)

Instruction		Example	Save	Brief description	Page
? !	lim	!lim 0 10 0 10 0 10	-	Set lower position limit to 0 and upper limit to 10 (assume unit is [mm] if dim was set to 2) for X Y Z	54
? !	limctr	!limctr x 1	-	Enable hardware limit switches for X axis, default = 1	54
? !	nosetlimit	!nosetlimit 1 1 1 1	Y	Disable setting/overwriting of software limits during cal and rm for all axes (here: X Y Z A), default = 0	55
? !	swtyp	!swtyp 1 0 1 !swtyp y 0 0 0	Y	Set limit switch type for all axes to NPN (pull-up) Set limit switch type for Y to PNP (pull-down)	55
? !	swpol	!swpol 1 0 1 !swpol z 1 0 1	Y	Set polarity of limit switches for all axes to active high (=1) Set polarity of limit switches for Z to active high	56
? !	swact	!swact 1 0 1 !swact y 1 0 0	Y	Enable cal and rm limit switches for all axes Enable cal limit switch for Y, disable ref and rm	57
? !	swdir	!swdir x 1	Y	Swap CAL and RM endswitch assignment of X axis	56
?	readsw	?readsw	-	Read states of all limit switches (1=active and actuated)	58
(?)	swin	swin	-	Read TTL signal level of all limit switch inputs (1=high)	58
(?)	statuslimit	statuslimit	-	Read current limit status „A“ = calibration done „D“ = rm done „L“ = limit switch modified by software „ “ = not yet modified	59

Calibration and Range Measure Instructions

Instruction	Example	Save	Brief description	Page

Calibration and Range Measure Instructions

Instruction		Example	Save	Brief description	Page
(!)	cal	cal	-	Perform a calibration move for all enabled axes, see 'axis'	60
(!)	rm	rm x	-	Perform a range measure move in X	62
(!)	vrm	vrm 75 50	-	Virtual range measure for a 75x50 microscope stage	63
? !	calmode	!calmode 2 2	Y	Set calibration/closed loop behavior X, Y to type 2	64
? !	calrequired	!calrequired z 1	Y	Z axis does not move until !cal is executed	64
? !	caltimeout	!caltimeout 60 60 10	Y	Set calibration timeout for X and Y to 1 minute, Z to 10s	65
? !	caliboffset	!caliboffset 1 1 1	Y	Set the cal zero-point 1mm aside lower limit switch (dim 2)	66
? !	rmoffset	!rmoffset 1 1 1	Y	Set rm end-position 1mm aside upper limit switch (dim 2)	66
? !	caldir	!caldir z 1	Y	Calibrate the Z-axis in positive direction	66
? !	calbspeed	!calbspeed 20	Y	Set the speed for move out of 'cal' and 'rm' limit switches for all axes to 0.2 [revolutions/s], range is [1...100]	68
? !	calrefspeed	!calrefspeed 10	Y	Set the speed for calibrating to the encoder reference for all axes to 0.1 [revolutions/s], range is [1...100]	68
? !	encrefvel	!encrefvel 5 5 5	Y	Set the speed for calibrating to the encoder reference for axes X,Y,Z to 5 [rev/s] if dim=2, [mm/s] if dim=9	69
? !	calpos	calpos	-	Read back the encoder position where the calibration switch was released	70
? !	refdir	?refdir y	Y	Read the direction for encoder reference search in Y axis	69
? !	calvel	!calvel x 10 0.5	Y	**Only if extmode = 1:** Set calibration velocities in X	71
? !	rmvel	!rmvel x 10 0.5	Y	**Only if extmode = 1:** Set range measure velocities in X	72
? !	autopitch	!autopitch x 1	Y	Measure pitch after cal move of X axis	72

Move Instructions

Instruction		Example	Save	Brief description	Page
(!)	moa	moa 10 10 10 moa y 20	-	Move X Y Z absolute to positions 10 10 10 Move Y axis to position 20 (unit depends on dim setting)	74
(!)	mor	mor 4 4 4 mor y -10.5	-	Move X Y Z relative by 4 (unit depends on dim setting) Move Y axis relative 10.5 backwards	74
(!)	m	m	-	Move relative again (use same parameters as defined by last '!mor' or '!distance' instruction)	75
? !	distance	!distance 1 1 1	-	Set distance for X Y Z 'm'-move (start with 'm' or '!m')	75
(!)	moc	moc x	-	Move X to center position between lower and upper limit switch, or between lower and upper software limits	75
(!)	go	go x 12.5	-	Move X to pos. 12.5, overwritable, for tracking applications	76
? !	speed	!speed 5 5 5 !speed y 0	-	Let X Y Z axis travel at 5 [revolutions/s] Stop the Y axis speed move	76
(!)	a	a	-	Abort move (Stop)	78
? !	delay	!delay 1000	Y	Delay the start of move instructions by 1000 ms	78
? !	pause	!pause 10	Y	Delay "position reached" autostatus response by 10 ms	78
? !	pos	!pos 0 0 1.5 ?pos z	-	Set current X Y positions to 0 and Z position to 1.5 Read current Z position	79
(!)	posclr	!posclr x	-	Reset the position offset that was manipulated by !pos	79
(!)	zero	!zero z	-	Set Z position and internal counter to 0 (e.g. filter wheel application)	80
(!)	clearpos	!clearpos z	-	Set Z position and internal counter to 0 (e.g. filter wheel application), not executable with measuring system	80

HDI: Joystick, Tackball and Handwheel Instructions

Instruction		Example	Save	Brief description	Page
? !	joy	!joy 0 !joy 2	Y	Switch joystick on(=2) or off(=0)	81
? !	joydir	!joydir 2 -2 0	Y	Set HDI axis direction: Y reversed, Z disabled	82
? !	joychangeaxis	!joychangeaxis 1	Y	Change Joystick X and Y axis (X→Y, Y→X)	82

HDI: Joystick, Tackball and Handwheel Instructions

Instruction		Example	Save	Brief description	Page
? !	joywindow	!joywindow 14	Y	Set idle window of the joystick center position, where a joystick deflection has no effect [0..100]	82
? !	joyvel	!joyvel z 1.5	Y	**Only if extmode = 1:** Set joystick velocity for Z to 1.5	83
?(!)	joyspeed	joyspeed 2 25	Y	Set joystick speed for speed button 2 “medium” to 25 rev/s	83
? !	keymode	!keymode 2	Y	Select joystick key mode 2 = high speed preselection	84
? !	keyspeed	!keyspeed x 5 20	Y	Set keymode joystick speed X low=5mm/s, high=20mm/s	85
?(!)	joycurve	!joycurve z 1	Y	Set joystick characteristic for Z ot linear	85
(?)	key	key	-	Read state of all joystick buttons (0=released, 1=pressed)	86
(?)	keyl	keyl	-	Read and clear latched state of all joystick buttons	86
? !	hwfactor	!hwfactor x 1	Y	One handwheel revolution in X is 1mm stage travel	87
? !	hwfactorb	!hwfactorb x 14	Y	One handwheel revolution in X is 14mm stage travel	87
? !	hwfilter	!hwfilter 0	Y	Switch off handwheel noise reduction	87
? !	tbfactor	!tbfactor 1 1	Y	Set trackball transmission factor in X and Y to default	88
(?)	zwheel	?zwheel	-	Returns 1 if HDI device has a Z-Wheel attached	89
?(!)	zwtravel	!zwtravel 1 0.25	Y	Set default Z-Wheel travel to 2.5 mm/rev	89
? !	zwaxis	!zwaxis a	Y	Assign Z-Wheel to A-axis	90
? !	zwfactor	!zwfactor 1	Y	Set Z-Wheel factor to 1:1 (default for Nanostep / Tango HDI devices)	90
? !	tvrjoy	!tvrjoy z	Y	Assign AUX-IO pulse&direction joystick to Z axis	91
? !	tvrjoyf	!tvrjoyf 1	Y	Set tvrjoy transmission factor to 1	91
(?)	hdi	hdi	-	Read ID number of the connected HDI device	92
! ?	hdimode	!hdimode 0 1	Y	Set hdimode bit 0 to 1 for ErgoDrive Toggle Mode	93
! ?	configaxsel	!configaxsel	Y	Toggle joystick Z-axis between axes Z and A by F4 key	94

Digital and Analogue I/O

Instruction		Example	Save	Brief description	Page
(?)	digin	digin digin 8	-	I/O Extension board: Read all digital inputs I/O Extension board: Read digital input 8	95
? !	digout	!digout 5 1 ?digout	-	I/O Extension board: Set digital output 5 to logic level 1 I/O Extension board: Read back all digital output levels	95
(?)	adigin	adigin adigin 2	-	Read all AUX-I/O digital inputs Read logic level of AUX-I/O digital input 2 only	96
? !	adigout	!adigout 3 1 ?adigout	-	Set AUX-I/O digital output 3 to logic level 1 Read back all digital output levels	96
(?)	anain	anain c 2	-	Read input of analogue channel 2	97
? !	anaout	!anaout c 1 17.5	-	Set analogue voltage of channel 1 to 17.5 percent (1.75V)	97
? !	stoppol	!stoppol 1	Y	Set AUX-IO stop input to active high	99
!	stop	!stop 0	-	Release stop condition (in latched stoppol modes 4 or 5)	100
? !	shutter	!shutter 1	-	Set AUX-IO shutter out signal to TTL high	100
(!)	flash	flash 0.1	-	Send a 100µs high pulse to AUX-IO TAKT_OUT (LED)	100

Encoder Instructions

Instruction		Example	Save	Brief description	Page
? !	encmask	!encmask 1 1 0	Y	Enable activation of X and Y encoders, disable Z	102
? !	enc	!enc 1 0	-	Manually activate X encoder (caution!), set Y to inactive	103
? !	encperiod	!encperiod 0.1	Y	Set signal period of X encoder to 100 µm	103
? !	encttl	!encttl x 1	Y	X encoder is TTL type (has no analogue sin/cos signal)	105
? !	encdir	!encdir y 1	(Y)	Reverse counting direction for Y encoder	104
? !	encvel	!encvel x 0.5	Y	Set auto-adjust velocity of X encoder to 0.5mm/s	104
? !	encref	!encref 0	Y	Disable usage of X encoder reference signal	105
? !	encnas	!encnas 1 0 0	Y	Enable NAS error signal input encoding for X encoder only	106
(?)	encrefstatus	encrefstatus x	-	Read X encoder reference signal state (1=on reference)	106

Encoder Instructions

Instruction		Example	Save	Brief description	Page
(?)	encrefstatusl	encrefstatusl x	-	Read latched X encoder reference signal state	106
(?)	encnasstatus	encnasstatus x	-	Read X encoder NAS signal state (1=NAS error)	107
? !	encerr	!encerr 0	-	Clear encoder error state for X axis (? response is 0 or e)	107
? !	encamp	?encamp x	-	Read X encoder signal amplitude in percent	107
? !	encpos	!encpos 1	-	?pos insruction returns for the encoder positions, if enc=1	108
(?)	hwcount	hwcount	-	Read all encoder positions (TTL counter, no interpolation)	108
(!)	clearhwcount	clearhwcount x	-	Set X axis hwcount to zero	108

MR Encoder Instructions

Instruction		Example	Save	Brief description	Page
? !	mra	?mra x	-	Read amplitude correction factor (sin/cos ratio) of X	110
? !	mro	?mro	-	Read offset correction value for all encoders	110
? !	mrp	!mrp x 0 0 0 0	-	Reset MR-signal peak-to-peak measurement result of X	111
?	mrt	?mrt z 2	-	List two measurement results of the Z input signals	111

Closed Loop Instructions

Instruction		Example	Save	Brief description	Page
? !	ctr	!ctr 1 1 1	Y	Set closed loop circuit X Y Z to “active until reached” mode	112
? !	ctrf	!ctrf 2.0	Y	Closed loop factor for X axis is set to 2.0	113
? !	ctrff	!ctrff 2 3.5	Y	Closed loop factors for X axis are set to 2 and 3.5	113
? !	ctrc	!ctrc 3	Y	Closed loop control is called every 3 millisecond	114
? !	ctrd	!ctrd 100	Y	Closed loop in target window for 100 milliseconds	114
? !	ctrt	!ctrt 200	Y	Closed loop control timeout after 200 milliseconds	114
? !	twi	!twi 0.01 0.01 0.01	Y	Set target window for X Y Z to 10µm (assume dim=2)	115
? !	ctrsm	!ctrsm x 1	Y	Set X behavior outside lock-in range to “slow closed loop”	115
? !	ctrs	!ctrs x 0.2	Y	Set lock-in range for X to 0.2mm (assume dim=2)	116
?	ctrstatus	?ctrstatus 1	-	Get Closed Loop active state of all axes	117
?	ctrdiff	?ctrdiff	-	Get Closed Loop position difference of all axes	118

Trigger Output Functionality[1]

Instruction		Example	Save	Brief description	Page
? !	trig	!trig 1	-	Enable trigger functionality (should be the last instruction)	119
? !	triga	!triga x	Y	Trigger function is related to X axis	119
? !	trigm	!trigm 0	Y	Select trigger mode 0	121
! ?	trigo	!trigo 1	Y	Select the default trigger output	122
? !	trigs	!trigs 40	Y	Set trigger output signal length to 40 microseconds	123
? !	trigd	!trigd 10	Y	Set trigger distance to 10 (mm if dim=2)	122
? !	trigcomp	!trigcomp 50	Y	Compensate a trigger signal delay of 50µs	123
? !	trigenc	!trigenc 1	Y	Select encoder signal as trigger source (if available)	124
? !	trigf	!trigf 1000	Y	Generate periodic trigger pulses with 1kHz	124
? !	trigbwidth	!trigbwidth 4.35	Y	Set Precise secondary trigger out signal length to 4.35µs	125
? !	trigbdelay	!trigbdelay 15.05	Y	Set Precise secondary trigger out to 15.05µs delayed	125
? !	trigbf	!trigbf 66000000	Y	Set Precise secondary trigger out frequency to 66 MHz	125
? !	trigcount	?trigcount	-	Read number of generated trigger events	126
(!)	trigger	trigger	-	Manually set trigger output (available in trigm 102, 103)	126

Snapshot - Trigger Input Functionality[1]

Instruction		Example	Save	Brief description	Page
? !	sns	!sns 1	-	Enable snapshot functionality (always 1 after power up)	128

[1] Function has to be enabled by factory, it is not available per default.

Snapshot - Trigger Input Functionality[1]

Instruction		Example	Save	Brief description	Page
? !	snsl	!snsl 0	Y	Set snapshot input signal to active low	128
? !	snsf	!snsf 10	Y	Set snapshot signal debounce filter to 10 milliseconds	128
? !	snsm	!snsm 0	Y	Set snapshot mode to 0 (0=capture pos, 1=move to pos)	130
? !	snsc	?snsc	-	Read number of snapshot events (=array fill size)	132
? !	snsi	!snsi 5	-	Set snapshot index to 6th entry (snsa 6)	132
? !	snsaxis	!snsaxis 1 1 0 0	-	X and Y axis moves wait for snapshot (in snsm mode 6)	133
? !	snsp	?snsp x	-	Read last captured X position	134
? !	snsa	?snsa 1	-	Read first position entry of snapshot array (all axes)	134
(!)	snse	snse 2	-	Generate SnapShot event F2	135
? !	snsv	?snsv 3	-	Read captured ANIN0 voltage in mV of 3rd snapshot entry	135
? !	prehome	!prehome 10 20 1	-	Set prehome positions X Y Z to 10 20 1 (unit depends on dim setting)	136
? !	home	!home 5 5 0	-	Set home positions X Y Z to 5 5 0 (unit depends on dim setting)	136

5. Instruction Syntax Description

Most instructions work in both directions (reading and writing). (?)! means the instruction accepts write and read access. The controller identifies a read instruction by a preceding '?', while '!' indicates writing to a parameter or executing an instruction. More information can be found in the **Introduction** chapter of this document.

Some examples of legal instruction syntax:
!*Instruction parameter1 parameter2 parameter3 parameter4*
!*Instruction parameter1 parameter2*
!*Instruction axis parameter*
!*Instruction*
?*Instruction axis parameter*
?*Instruction*

6. Error Numbers and their possible Root Cause

0	no error
1	no valid axis name
2	no executable instruction
3	too many characters in command line
4	invalid instruction
5	number is not inside allowed range
6	wrong number of parameters
7	either ! or ? is missing
8	no TVR possible, while axis active
9	no ON or OFF of axis possible, while TVR active
10	function not configured
11	no move instruction possible, while joystick enabled
12	limit switch active
13	function not executable, because encoder detected
21	multiple axis moves are forbidden (e.g. during initialization)
22	automatic or manual move is not allowed (e.g. door open or initialization)
27	emergency STOP is active
29	servo amplifier are disabled (switched OFF)
30	safety circuit out of order
70	wrong CPLD data
71	ETS error
72	parameter is write protected (check lock bits)
73	internal error, e.g. eeprom data corruption
74	closed loop switched off due to parameter change
75	could not enable axis correction, or axis correction was disabled
76	io extension card error

7. Controller Informations

You may read the firmware version by sending the instruction '**version**' to the controller. The instruction '**det**' gives you further details of which options and features are enabled. Each controller has its own unique serial number readable with the instruction '**readsn**'.

7.1. version (Read detailed Version information)

Syntax: ?version or version
Parameter: none or 1

Description: This instruction gives detailed information about the firmware version.

Sending the version instruction with parameter 1 returns the Nanostep / Tango firmware version number only.

Example:
```
?version
NANOSTEP / TANGO-DT-S, Version 1.37, Aug 12 2008 , 16:39:01

?version 1
1.37
```

Response syntax: Character string including controller type, firmware version and build date separated by a comma:

TANGO	Fixed string identifying the Tango controller
-DT	Desktop version
-PCI	PCI card version
-S	Nanostep / Tango short card version (PCI-S, DT-S)
-MINI	TANGOmini
-C	Motorized Stage with integrated Controller
e	Tango PCI-E card version (PCIe, DTe)
Version 1.37	Firmware version number
Aug 12 2008	Firmware build date
16:39:01	Firmware build time

7.2. det (Read detailed Configuration)

Syntax: ?det or det
Parameter: none

Description: Read Detailed information of the controller configuration.

Response: The response is a decimal integer number. Its bit pattern represents the configuration as described below:

```
0x0    1   1Vpp encoder is configured
0x0    2   MR encoder is configured
0x0    4   TTL encoder is configured
0x0   3    this is the number of configured axes (e.g. 3)
0x0  1     Display is configured
0x0  2     Speedpoti is configured
0x0  4     Hand wheel is configured
0x0  8     Snapshot is configured
0x0 1      TVRin is configured
0x0 2      Trigger out is configured
0x0 8      TVRout is configured
0x1       digital I/O extension 24in+8out
0x2       digital I/O extension 12in+8out
0x4       Trackball is configured
0x8       ETS available
```

Individual configured options can be identified by applying a logic AND mask to the returned value.
E.g. (val & 0x0800) to identify if Snapshot instructions are available/configured by factory, (val & 0x02000) for Trigger.

Example: Assume the ?det response is 81697, which is 0x13F21 hex. This number means in detail, that the controller is configured for:

```
1 => Built in digital I/O extension with 24in + 8out
3 => TVRin and Trigger out
F => Display, Speedpoti, Hand wheel and Snapshot
2 => 2 axes
1 => 1Vpp encoder
```

7.3. detext (Read Extended detailed Configuration)

Syntax: ?detext or detext
Parameter: none

Description: Read Detailed information of the controller configuration as multi-line readable text (description strings). Each line is terminated by a [CR].

Response: Multi line reply, containing the configuration number as hex value (bit representation as describet with ‘det’), and the meaning of it as multi line text.

Example:

```
detext     =>     02832
                  = MR Encoder
                  = 3 Axes
                  = Snapshot
                  = Trigger out
```

7.4. readsn (Read Serial Number)

Syntax: ?readsn or readsn
Parameter: none

Description: Reads the serial number of the Nanostep / Tango controller.

Response: The controller returns its unique serial number as ASCII character string. The syntax is YYWWTNXXX.

YY year of manufacturing
WW week of manufacturing
T type identifier
N in hardware available axes (may differ from **?maxaxis**)
XXX index number

Example: ?readsn => 083303007

7.5. ver (Read default Version Number)

Syntax: ?ver or ver
Parameter: none

Description: Read the default controller version info. The first digit is the number of configured axes. The second digit is the maximum possible motor current in ampere.
To read the Nanostep / Tango firmware version, please use **"version"**.

Response syntax: Vers:*LSnm.xx.xxx* (in some cases "Vers:*ESnm.xx.xxx*")

"Vers:LS" Fixed character string (also "Vers:ES" possible)
n Number of configured axes: 1, 2, 3, or 4
m Maximum Current: 1=1.25A, 2=2.5A, 3=3.75A
x Fixed numbers

Example: ?ver => Ver:LS32.00.038

7.6. iver (Read internal Version Number)

Syntax: ?iver or iver
Parameter: none

Description: Read the internal version information string. Mostly unused.
To read the Nanostep / Tango firmware version, please use **"version"**.

Response syntax: 14 characters, e.g. T[DD].[WW].[YY]-[NNNN]
[DD] = Day of Week
[WW] = Week
[YY] = Year
[NNNN] = Number

Example: ?iver => T04.35.020004

7.7. uptime (Read Controller Up Time)

Syntax: ?uptime or uptime
Parameter: none

Description: This instruction returns the power-on time of the controller since it was switched on or resetted.

Response: Time in seconds.

Example: uptime => 8731

7.8. temp (Read Case Temperature)

Syntax: ?temp or temp
Parameter: none

Description: Read the ambient temperature inside the controller.
Remarks: Not all Nanostep / Tango controllers provide a temperature sensor.

Response: Temperature in [°C] with one decimal place.

Example: temp => 28.9

7.9. maxaxis (Read number of available Axes)

Syntax: ?maxaxis
Parameter: none

Description: Read the number of available (factory configured) axes.
1, 2, 3 or 4.

Response: Number of available axes.

Example: ?maxaxis => 3

7.10. maxcur (Read Maximum Motor Current)

Syntax: ?maxcur
Parameter: x, y, z, a or none
Optional parameter 1

Description: Read the maximum possible motor current which can be set by **!cur**.

A) Maxcur called without parameter:
Maximum motor current which the power amplifier can deliver.

B) Maxcur called with parameter “1”:
Additional soft motor current limitation, defined from ETS.

Response: maximum motor current in Ampere [A] (e.g. “1.25” or “1.00”)

Examples:
?maxcur y read maximum adjustable motorcurrent of Y axis only
?maxcur read maximum adjustable motorcurrent of all available axes (e.g. returns 1.25 1.25 1.25 1.00)
?maxcur y 1 read motor current soft limit of Y axis only (e.g. set by ETS)

```
?maxcur 1          read motor current soft limit of all axes     (e.g. set by ETS)
```

7.11. etspresent (Read ETS Detect State)

Syntax: ?etspresent
Parameter: none

Description: Check if an ETS was detected by the Nanostep / Tango (during power-up).

0 = No ETS found at the corresponding address
1 = ETS was found at the corresponding address (is available)

Remarks: If more than one ETS is found, the first one (lowest address) is treated as the “main” ETS, the ETS with higher address only for the there defined axis specific parameters (e.g. axis 3).

Response: ASCII string of 4 characters, 0 or 1
[ETS ADR0][ETS ADR1][ETS ADR2][ETS ADR3]

Example:
```
?etspresent  => 0000   (no ETS connected)
?etspresent  => 1000   (ETS found at address 0, usual case)
?etspresent  => 1010   (ETS found at address 0 and 2)
```

7.12. stagesn (Read Connected Devices Serial Number)

```
Syntax:          ?stagesn
Parameter:       none or -1,0,1,2,3

Description:     Read the device serial number from the ETS.
                 If the motor axis provides the ETS identification circuit, the
                 serial number of the axis or connected unit (e.g. a microscope
                 stage) is returned.

                 Call parameter options:
                 -  None: 4 serial numbers are returned, one for each possible
                          ETS address (0,1,2,3)
                 -  -1  : 1 Serial number is returned, of the main ETS (usually
                          also the only connected ETS, recommendet instruction)
                 -  0-3 : Addresses an individual ETS, usually only ETS#0 is
                          Available (which then also responds with -1 param.)

Response:        ASCII string(s) of 8 or 9 characters.
                 The syntax is YYMMDDXXX or "---------" if no ETS available.

                 YY    year  of manufacturing
                 MM    month of manufacturing
                 DD    day   of manufacturing
                 XX(X) index number

Example:         ?stagesn     => 120328015 --------- --------- ---------
                 ?stagesn -1  => 120328015
                 ?stagesn 0   => 120328015
                 ?stagesn 1   => ---------

                 ?stagesn -1  => 07090305

                 ?stagesn     => --------- 120328015 --------- ---------
                 ?stagesn -1  => 120328015
                 ?stagesn 0   => ---------
                 ?stagesn 1   => 120328015
```

8. Communication Interface Settings

8.1. baud (Baud Rate)

Syntax: !baud or ?baud
Parameter: 1200, 2400, 480, 9600, 19200, 38400, 57600 or 115200

Description: Set or read the baudrate of the serial COM Port interface.

It applies to devices with a true RS232 serial connection, as available with Nanostep / Tango-DT and Tango-mini, and the Pilot stage or Tango-mini with USB cable.

Remarks: For PCI/PCI-E card versions or Nanostep / Tango-DT with USB interface this instruction has no effect, as communication is managed by the driver at a very high, internally fixed baudrate. In this case it does not matter which baudrate the virtual COM port is opened with, it has no effect on performance.

After sending this instruction the PC has to re-open the COM Port with the new baudrate, else no communication is possible. Then a **"!save"** instruction may be sent to permanantly store the new baudrate in the controller.

Response: Current baud rate of the controller

Examples:
!baud 57600 Set the baud rate to 57600 [Bd]
?baud Read currently set baud rate

8.2. cts (Enable/Disable RS232 Hardware Handshake)

Syntax: ?cts or !cts
Parameter: 0 or 1

Description: Enable or disable RTS/CTS hardware handshake of the RS232 and USB Virtual COM Port interfaces. For PCI bus communication this instruction has no effect.

Remarks: The COM port of the PC has to be opened in the same hardware handshake mode.

0 : no handshake (default)
1 : RTS/CTS handshake

Response: Currently selected cts mode

Examples:
?cts read current handshake mode
!cts 0 disable RTS/CTS handshake (default, recommended)
!cts 1 enable RTS/CTS handshake

9. System Instructions

9.1. save (Save Parameters)

Syntax: !save or save
Parameter: none

Description: The save instruction permanently stores the parameter settings (e.g. spindle pitch, motor current) to the Nanostep / Tango controller. These parameters will be applied as default values after each consecutive power-on or reset. Executing a save comand always returns the "OK..." string when writing to the internal memory has completed successfully.

Response: ASCII string "OK..." or "ERR"

Example: save
==> OK... (The currently used controller parameters are saved and from now on used as defaults)

9.2. restore (Restore Saved Parameters)

Syntax: !restore, restore or ?restore
Parameter: none or -1

Description: Reload or reset the saved parameters.

When called without parameter (restore, !restore, ?restore)
The controller reloads the parameter settings from its nonvolatile memory, like performed at power-on or reset. But restore does not affect or restart the entire hardware.

?restore returns "OK..." or "ERR" (like the save instruction), In the other cases there is no reply. ?err might be sent once after the restore instruction and will reply after restore has completed.

When called with parameter "-1" (restore -1, !restore -1)
The saved parameters (nonvolatile memory) will be deleted and set to the firmware defaults. The parameters then have to be checked and set to the hardware requirements by the user. Else it may cause damage (due to overcurrent, wrong pitch, limit switch types etc). Software reset is performed automatically.

There is no reply to the restore -1 instruction, ?err polling may be required as described with the software "reset".

Response: none, or "OK..." or "ERR" when using ?restore

Example:
```
restore          (reload the saved parameter set)
?restore         (like restore, but with OK/ERR reply)
restore -1       (reset the saved parameters to default)
```

9.3. reset (Force a Software Reset)

```
Syntax:           !reset or reset
Parameter:        none

Description:      The controller is forced to perform a software reset. It is a
                  restart similar to power on. Rebooting from reset will take
                  more than 1 second, where the controller is not responding.
                  There is no reply to a software reset.

Remarks:          Wait for reboot after Reset:
                  For knowing if the controller has rebooted and is ready, data
                  may be polled until it responds again. E.g. send "?err" until
                  the controller responds:
                  Send ?err [wait 0.5s for response]
                  Send ?err [wait 0.5s for response]
                  ...
                  Send ?err [wait 0.5s for response]
                  Send ?err => 0 [Response, controller is ready]

Response:         none

Example:          reset
```

9.4. pa (Enable or Disable the Power Amplifiers)

```
Syntax:           !pa or !poweramplifier
                  ?pa or ?poweramplifier
Parameter:        0 or 1

Description:      Switch all motor amplifiers on/off or read amplifier state.

                  If switched off, no motor current is flowing (high impedance).
                  To switch off individual axes, use the 'axis -1' instructions.

                  Amplifier switch off can also be caused by a short circuit,
                  the PSE pin functionality or loss of motor supply voltage.
                  Then an internal error (error 29) is generated and the status
                  LED flashes. ?pa will return 0. After removing the switch-off
                  cause, the amplifiers can be switched on again by !pa 1.

                  1 = Amplifiers on
                  0 = Amplifiers off

Remarks:          With amplifiers off it can not be ensured that the axis
                  position will be retained. A closed loop will be deactivated.

Response:         amplifier on state, 0 or 1

Example:          !pa 1       Switch on all amplifiers
                  ?pa         Read amplifier on state

Sequence example: !pa 0
                  ?pa         => 0
                  ?err        => 0

                  External event: PSE, short circuit or no motor voltage applied
                  ?pa         => 0
```

```
?err          => 29
```

9.5. ipreter (Select Instruction Set)

Syntax: !ipreter or ?ipreter
Parameter: 1, 2, 3 or 4

Description: Instruction set of the Nanostep / Tango controller.
The Nanostep / Tango controller provides 4 different instruction sets, also called “interpreter”.
It is recommended to use the default interpreter 1, as it is the native language and supports the most complex instruction set available.
Other instruction sets may be used for compatibility to existing applications. They are described in separate manuals.

INTERPRETER NR.	
0	Not supported! (old register instruction set)
1	Default instruction set (Native), as described in this manual
2	VENUS-1 and VENUS-2
3	LUDL MAC5000
4	ASI MS-2000 (Available with Firmware >= 1.46)

To return from the VENUS instruction set (2), please enter the string “1 setipreter” and press enter (or send an ASCII [CR]).
For other instruction sets please refer to the corresponding instruction set description.

Response: 1, 2, 3 or 4

Example:
!ipreter 2 => Switch the interpreter to the VENUS instruction set
?ipreter => Responds the currently selected interpreter

10. Operating Modes

10.1. Extended Mode

Activating Extended Mode will change the controller's behavior. Also there are new instructions available for setting calibrate and range measure velocities.
Note: When initializing the controller, the desired Extended Mode should be set directly after setting **dim** and before setting gear, pitch, vel etc.

Calibration in extmode = 0:

!vel --> The velocity for moving towards an endswitch has to be set everytime before starting a **cal** / **rm** move.
!calbspeed --> There is only one velocity for all axes to travel out of the endswitch. The unit is 1/100 rev/s.

Calibration in extmode = 1:

!vel has no influence to the !cal and !rm move, **calbspeed** is no longer used.
Now the calibrate (**cal**) and range measure (**rm**) velocities can be assigned once and will be used as speed especially for this instructions.
!calvel --> Set velocities for moving towards and out of the cal endswitch (E0)
!rmvel --> Set velocities for moving towards and out of the rm endswitch (EE)

Additional differences when in extmode = 1:

If the pitch or gear parameter is changed, all parameters which are in revolutions/s (e.g. vel) are recalculated internally. So the axis velocities will remain the same.

joyvel --> The joystick velocity can (and has to be) set independently from **vel** by the **joyvel** instruction.

The **?lim** instruction, when requested without an axis specifier, now returns all limits in a correctly formatted way.

10.1.1 extmode (Switch to Extended Mode)

Syntax: !extmode or ?extmode
Parameter: 0 or 1

Description: This instruction switches the Nanostep / Tango controller into extended mode. This mode offers improved behavior and more instructions than the standard interpreter. For further information please refer to the **Extended Mode** Chapter 10.1.

0 = default, compatible interpreter mode
1 = extended interpreter mode

Response: currently used extmode, 0 or 1

Examples:
!extmode 1 Set controller behavior to extended mode
?extmode Read extended mode setting

10.2. Scan Mode

In Scan Mode the controller executes move instructions with a vector velocity.

10.2.1 scanmode (Switch to Scan Mode)

Syntax: !scanmode or ?scanmode
Parameter: 0, 1 or 2

Description: This instruction switches the Nanostep / Tango controller into scan mode, which may be used for continuous path control. This mode applies a constant vector velocity for automatic moves (moa, mor) which is set by **'scanvel'**.

0 = normal operation (default, no scan mode)
1 = scan mode 1
2 = scan mode 2

Scan mode 1:
- The resulting travel velocity of automatic moves is **scanvel**.
- The individual **'vel'** settings are ignored.
- Applies to single axis and vector moves, e.g. "!moa x 10", "!moa 10 20"

Scan mode 2:
- Similar to scanmode 1, but individually started axes now travel at their original **'vel'** settings. May be useful e.g. when the Z-axis controls the focus.
- The resulting travel velocity of a vector move is **scanvel**.
- The individual **'vel'** settings are used for single axis move. e.g. "!moa z -10"
- Applies to vector moves of 2 or more axes only, e.g. "!moa 10 20"

Response: Scanmode (automatic move mode) as integer

Examples:
!scanmode 1 Set controller into scanmode 1
?scanmode Read controller scanmode

"!vel 20 20 10" "!scanvel 0.1" "!scanmode 2"
"!moa 50 100" (vector move with scanvel)
"!mor z 1.5" (single axis move executed with vel z: 10mm/s)

10.2.2 scanvel (Scanmode Vector Velocity)

Syntax: !scanvel or ?scanvel
Parameter: 0.000001 to 1000 [mm/s]

Description: This instruction sets or reads the **'scanmode'** vector velocity in millimeter per second. It is also used for the snapshot dissection mode (snsm 3) continuous path velocity. There is only one parameter.

Response: Currently selected velocity in [mm/s]

Examples:

```
!scanvel 10        Set scanmode vector velocity to 10 mm/s
?scanvel           Read scanmode velocity
```

10.2.3 modulomode (Define Linear or Turntable Modes)

Syntax: !modulomode or ?modulomode
Parameter: x, y, z, a or none
0, 1, 2, 3 or 4

Description: This instruction sets or reads the axis modulo mode.
Modulo mode switches the specified axes from linear into a turntable mode that remains within [0…360[° or [0…1[depending on '**dim**'.
1 linear and 4 turntable modes are available:

0 : Modulo Mode off (default mode, e.g. for linear axes)

1 : Travel shortest distance to target position
(automatically decides to travel forward or back)

2 : Only travel in positive direction
(may result in traveling up to one additional revolution)

3 : Only travel in negative direction
(may result in traveling up to one additional revolution)

4 : Do not travel over Zero
e.g. for swiveling axes <360° with limited operation range or as cable tear-off protection)

Modes 1,2 and 3 ignore the upper and lower limits of the axis. While mode 4 uses the limits (**cal**,**rm**,**lim**) in order to narrow the possible operating range.

Remarks: Modulo Mode 1, in conjunction with the !speed instruction, can be used to achieve an endless rotating mode (pump, fan, etc).

Response: Currently selected modulo mode

Examples:
```
!modulomode 0 0 1 (set Z axis to modulo mode 1, X and Y to standard linear mode)
!modulomode a 4   (set A axis to modulo mode 4)
?modulomode       => 0 0 0 (returns modulo mode of all axes, e.g. 0s)
?modulomode x     => 1     (returns modulo mode of X axis, e.g. 1)
```

11. Controller States and Error Messages

11.1. autostatus (Set Autostatus to required behavior)

Syntax: !autostatus or ?autostatus
Parameter: 0, 1, 2, 3 or 4

Description: Select auto response behavior for completion of move and calibration instructions. The power-on default is mode 1. Autostaus mode can not be saved by the '**save**' instruction.

0 : Disable automatic status replies
(Except '**save**' instructions will still return either "OK..." or "ERR")

1 : The Default.
Position reached response after each automatic move (moa, mor, cal, rm) (a 5 character string with e.g. '@' for each configured axis is returned by the controller. Please also refer to '**statusaxis**' for further information. Autostatus 1 is the default configuration after power-on.

2 : The controller responds with the 'position reached' message of mode 1, plus the **status message** "OK..." or "ERR".

3 : A simple <CR> (0x0d hex) is returned to indicate that the move is completed. It can be used to improve performance for higher vector throughput, but contains less information e.g. concerning possible errors.

4 : Echoes the sent instruction including parameters.

Example: Assume a controller with 3 axes and autostatus set to 1. After completion of a move (moa, mor, m, a) the controller will return a 5 ASCII character string "@@@-." which means move completed.

!autostatus 0 Switch off autostatus ("**statusaxis**" has to be polled to find out if the axis moving or stopped)

!autostatus 1 Set autostatus to the default behavior

!autostatus 3 Set autostatus to <CR> response for low communication overhead

?autostatus Read the currently selected autostatus

11.2. statusaxis (Read State of Axis)

Syntax: ?statusaxis or statusaxis or sa
Parameter: x, y, z, a or none

Description: Statusaxis responds the state of each axis.
Similar to the '**autostatus** 1' response for move instructions, but with an additional '-' after the dot.
It can be used for polling move states when in 'autostatus 0' mode, where no automatic response is generated.
Every response except of 'M' means the axis has stopped for some reason and may be ready for a new move instruction.
It is recommended to check the returned ASCII character for != 'M' (not equal to 'M', 0x4D hex).

Response: 6 ASCII characters: [STATUS X][STATUS Y][STATUS Z][STATUS A].-

@ => Axis is not moving and ready
M => Axis is moving
J => Axis is ready and may also be controlled manually (by joystick)
C => Axis is in closed loop
S => Limit switches are actuated and prevent further automatic move
A => ok response after cal instruction
D => ok response after rm instruction
E => not o.k. response after cal or rm, if an error occurred during cal instruction (e.g. a limitswitch is not working properly)
U => manual adjustment (e.g. 1st setup)
T => Timeout occurred (refer to '**caltimeout**' instruction)
=> Axis is not enabled, not available in hardware

Example: Assume ?statusaxis returns @@@-.-
This means three axes are enabled and ready to move.

```
?statusaxis   (JM--.- = 2 axis controller, X is ready, Y is moving)
sa            (e.g. may return A@@-.- after calibrating the X-Axis)
sa x          (e.g. may return M if axis is moving)
```

11.3. status (Read the Controller Error State)

Syntax: ?status or status
Parameter: none

Description: The ?status instruction responds with the current state of the controller. Which is either 'OK...' or an 'ERR' with the error number. The error number description can be found in chapter **Error Numbers**. Also refer to '**err**' and '**help**' instructions.

Response: OK... or ERR with error number

Example: ?status => ERR 4
?status => OK...

11.4. err (Read Error Number)

Syntax: ?err or err, !err
Parameter: none

Description: The instructions err or ?err return the controller error state or 0, if no error occurred. The error state wil be updated or re-set by the next instruction.
If not a permanent error (like e.g. 29) the error state may be cleared to zero by sending !err.

Response: Error number as decimal value
(refer to Chapter 6. "**Error Numbers**")

Example: err (may return a 0)
?err (same as err)
!err (clear error state if no permanent error)

11.5. help (Read Error Number with Description String)

Syntax: ?help or help
Parameter: none or requested error number

Description: The instruction help returns a text string. It contains the error state with appended error description. The error state is not cleared to zero. Please also refer to the '**err**' instruction.

Called without a parameter:
It returns the controller's error state with description

Called with a parameter (error number):
It returns this error number with the corresponding comment

Response: Error number as decimal value, error description as ASCII text

Example: help => ERROR 0,no error (assuming there is no error)
help => ERROR 5,number outside range
help 29 => ERROR 29,servo amplifier off

11.6. service (Print Service Information to Terminal)

Syntax: ?service or service
Parameter: none

Description: The instruction service returns a multi-line parameter and state list of the controller. It may be used for debugging or in case of service requests. Either a terminal program or SwitchBoard version 1.19 and above can be used.

Response: Many lines of text including e.g. serial number, parameters, states etc. Each line terminated by a [CR].

Example: service

11.7. pci (Is PCI Bus)

Syntax: ?pci or pci
Parameter: none

Description: Check if the Nanostep / Tango controller is used as PCI/PCI-E card
(plugged into a PC slot).

0 = Controller is a desktop version
1 = Controller is a PCI or PCI-E card, plugged in the PCI(-E) slot of a computer (here: no RS232 or USB communication)

Response: 0 or 1

Example: pci => 0 (e.g. a Nanostep / Tango Desktop)

11.8. isvel (Read Actual Velocities)

Syntax: ?isvel or isvel
Parameter: x, y, z, a or none

Description: Read the actual velocitie(s) at which the axis is currently traveling. Unlike **'?vel'** or **'?speed'** this instruction returns the currently traveled (true) speed of the axes, even when contolled by a HDI device.

Optional read-resolution: As an option to read the value with higher precision, the number of required decimal places can be specified with the query "?isvel [0…16 decimal places]". If no precision is defined, the default resolution is 3 decimal places.

Response: Actual axis velocity in [mm/s]

Example:
?isvel => Read actual velocity of all axes
?isvel y => Read actual velocity of the Y axis (e.g returns 10.000)
?isvel 4 => Read actual velocity of all axes with 4 decimal places (0.0000)
?isvel y 6 => Read actual velocity of the Y axis with 6 decimal places

11.9. maxpos (Maximum Position)

Syntax: ?maxpos
Parameter: x, y, z, a or none

Description: Read the maximum position value which the controller can accept due to internal limitations. It depends on e.g. the selected pitch, gear or motorsteps.

Response: Maximum position value of the axes
(unit depends on **'dim'** setting)

Example:
?maxpos => 2600.0000 2600.0000 2600.0000
?maxpos x => 2600.0000 (X axis accepts positions from -2600mm to +2600mm)

12. General Adjustments

With the following instructions the parameters of the controller are widely scalable to the given mechanic construction and to customer requirements. The controller is adaptable to the requested requirements.

12.1. dim (Unit for Positions and Velocities)

Syntax: !dim or ?dim
Parameter: x, y, z, a or none
0 to 9

Description: The dim instruction sets the unit (here "dimension") of the input and output parameters related to length, e.g. position or move instructions. Dim 9 also sets the velocity parameters to mm/s (e.g. '**vel**', '**speed**'), which else remain in motor revolutions per second.

0 => Micro steps
1 => µm
2 => mm (default, velocities in motor revolutions/s)
3 => 360°
4 => revolutions
5 => cm
6 => m
7 => inch
8 => mil
9 => mm (difference to mode 2: all velocity units in mm/s)

Remarks: For dim 3 (=360°) and 4 (=revolutions) it is recommended to set the **spindle pitch** to 1mm.
In dim mode 0 the Microstep resolution can be specified by the '**usteps**' instruction, in order to match the required amount of steps per revolution (e.g. 40000, 54000, 360). Fractional values can be used for positioning in Microsteps mode also.

Response: Current dim settings

Examples:

```
!dim 4 1    set dim unit for X to [revolutions] and for Y to [µm]
!dim z 9    set dim unit for Z to [mm and mm/s]
!dim 2 2 2  set dim unit for axes X, Y and Z to [mm]
?dim        read dim unit for all axes
?dim a      read dim unit of A-axis only
```

12.2. pitch (Spindle Pitch)

Syntax: !pitch or ?pitch
Parameter: x, y, z, a or none
0.0001 to 72 [mm/rev]

Description: This instruction sets or reads the spindle pitch which defines the axis travel distance in millimeter per motor (or gear) revolution.

Optional read-resolution: As an option to read the parameter with higher precision, the number of required decimal places can be specified with the query "?pitch [0…16 decimal places]". If no precision is defined, the default resolution is 4 decimal places.

Remarks: If the required pitch value is an infinite number due to a 1/x function, the '**gear**' parameter can be used instead or in combination.

Response: currently used spindle pitch in [mm per motor revolution]

Examples:

!pitch 4 1	set spindle pitch X=4[mm] and Y=1[mm]
!pitch z 28.895	set spindle pitch Z=28.895[mm]
?pitch	read spindle pitch of all axes (e.g. returns 1.0000 1.0000)
?pitch a	read spindle pitch of A-axis only
?pitch 9	read spindle pitch of all axes with 9 decimal places
?pitch y 6	read spindle pitch of Y-axis with 6 decimal places (1.000000)

12.3. gear (Gear Ratio)

Syntax: !gear or ?gear
Parameter: x, y, z, a or none
0.001 to 1000

Description: This instruction sets or reads the axis gear ratio. If there is no gearbox mounted to the axis, this parameter should be left at its default value of 1.

Optional read-resolution: As an option to read the parameter with higher precision, the number of required decimal places can be specified with the query "?gear [0…16 decimal places]". If no precision is defined, the default resolution is 3 decimal places. Please also refer to the examples below.

Remarks: If the required pitch value is an infinite number due to a 1/x function, the '**pitch**' parameter can be used instead or in combination.

Response: currently used gear ratio

Examples:

!gear 10	set gear ratio X=1:10
!gear 4 1	set gear ratio X=1:4 and Y=1:1
!gear z 12.5	set gear ratio Z=1:12.5
?gear	read gear ratio of all axes
?gear a	read gear ratio of A-axis only (e.g. returns 1.000)
?gear 9	read gear ratio of all axes with 9 decimal places

```
?gear z 10          read gear ratio of Z-axis only with 10 decimal places
```

12.4. motorsteps (Motor Steps Per Revolution)

Syntax: !motorsteps or ?motorsteps
Parameter: x, y, z, a or none
[multiples of 4]

Description: This instruction sets the steps per revolution of the motor, which can be found in the datasheet. Common motors have 200 steps per revolution (1.8° full step). This is the Nanostep / Tango default value. Other motors may have e.g. 400, 500 or 24 steps per revolution. It is essential for operation to have this parameter set according to the datasheet.
The motor steps paramerer must be a multiple of 4 in the range of 4 to 65534.

Response: Selected motorsteps of the stepper motor(s)

Examples:

!motorsteps 200 200 400	set motor steps for X and Y to 200 and Z to 400
!motorsteps x 500	set motor steps for X to 500
?motorsteps	read motorsteps of all axes
?motorsteps a	read motorsteps of A-axis only

12.5. accel (Acceleration)

Syntax: !accel or ?accel
Parameter: x, y, z, a or none
0.0001 to 20 [m/s²]

Description: This instruction sets or reads the acceleration which is used for all moves, the speed instruction and manual control by HDI devices.

Optional read-resolution: As an option to read the parameter with higher precision, the number of required decimal places can be specified with the query "?accel [0…10 decimal places]". If no precision is defined, the default resolution is 2 decimal places.

Remarks: In case of a stop event, '**stopaccel**' is used instead.

Response: Currently used acceleration in m/s²

Examples:

!accel 0.5	set acceleration X=0.5[m/s²]. Other axes are not affected
!accel 1 0.55	set acceleration X=1.0[m/s²] and Y=0.55[m/s²]
!accel z 0.2	set acceleration Z=0.2[m/s²]. Other axes are not affected
?accel	read all axes for their current acceleration
?accel z	read Z axis for its acceleration
?accel 6	=> 0.500000 0.123456 0.200000
?accel y 4	=> 0.1235

12.6. accelfunc (Acceleration Ramp Function)

Syntax: !accelfunc or ?accelfunc
Parameter: x, y, z, a or none
0, 1 or 2

Description: Select the acceleration ramp type for automatic moves (e.g. m, moa, mor, moc, cal, rm).

0 = Linear acceleration/deceleration ramp
1 = sin² acceleration/deceleration ramp
2 = reserved, currently same as 1: sin²

Remarks: The acceleration ramp for '**go**' and '**speed**' instructions and manual control (HDI) always remains linear accelerated.

Response: Currently used acceleration type

Examples:

!accelfunc 1	set accel function X to sin², other axes are not affected
!accelfunc x 1	set accel function X to sin², other axes are not affected
!accelfunc 1 1 0	set accel function in X and Y to sin², Z to linear accel.
?accelfunc	read acceleration ramp function of all axes
?accelfunc z	read acceleration ramp function of Z axis only

12.7. stopaccel (Emergency Stop Deceleration)

Syntax: !stopaccel or ?stopaccel
Parameter: x, y , z, a or none
0.001 to 200 m/s²

Description: This instruction sets the deceleration for emergency stop conditions. It will be used by:

- abort instructions
- active stop input
- a 'cal' or 'rm' move (at the limit switch)
- when detecting an unexpected limit switch

Optional read-resolution: As an option to read the parameter with higher precision, the number of required decimal places can be specified with the query "?stopaccel [0…10 decimal places]". If no precision is defined, the default resolution is 2 decimal places.

Response: Deceleration for stop conditions

Examples:

!stopaccel 1 1 2	Set the stop deceleration for X and Y to 1 and Z to 2 [m/s²]
!stopaccel x 1.5	Set the X stop deceleration to 1.5[m/s²]
?stopaccel	Returns the stop deceleration of all axes
?stopaccel z	Returns the stop deceleration of Z axis only (e.g. 1.50)
?stopaccel 6	Returns stop deceleration of all axes with 6 fractional digits
?stopaccel z 9	Returns stop deceleration of Z axis with 9 fractional digits

12.8. vel (Velocity)

Syntax: !vel or ?vel

Parameter: x, y , z, a or none
0.000001 to 200 [rev/s] (or up to 3000 [mm/s] if dim = 9)

Description: Velocity for automatic moves, cal**, rm** and HDI**

Except of dim=9 the unit is always motor revolutions per second. In dim=9 the unit is [mm/s].

Optional read-resolution: As an option to read the parameter with higher precision, the number of required decimal places can be specified with the query "?vel [0…16 decimal places]". If no precision is defined, the default resolution is 3 decimal places.

Remarks: If **extmode**=0 (default), vel is also used for
1) the HDI (joystick) velocity
2) the cal and rm instructions
In extmode=1 there are separate parameters (joyvel,calvel,…).

The '**velfac**' instruction can be used in addition to 'vel', but is not necessary or recommended.

Response: Currently selected velocity

Examples:

!vel 1.0 15	set velocity X=1[revolution/s] and Y=15[revolution/s]
!vel z 0.1	set velocity Z=0.1[revolution/s]
?vel	read velocity of all axes
?vel x	read velocity of X axis only
?vel 6	=> 20.000000 0.123456 5.000000
?vel y 4	=> 0.1235

12.9. velfac (Velocity Factor)

Syntax: !velfac or ?velfac
Parameter: x, y , z, a or none
0.01 to 1.00

Description: This instruction sets or reads the velocity factor, which is used for all consecutive automatic moves. It is internally multiplied to the velocity (vel).

Response: Currently used velocity factor [0.01 to 1.00]

Examples:
?velfac read velocity factor of all axes
?velfac z read velocity factor of Z axis only
!velfac x 0.1 set velocity factor of X axis to 1/10 of specified velocity
!velfac 1 1 1 set velocity factor of X,Y,Z to specified velocity (default)

12.10. secvel (Secure Velocity)

Syntax: !secvel or ?secvel
Parameter: x, y , z, a or none
0.000001 to 100 [mm/s]

Description: The security speed limitation is used as long as the axis is not calibrated and range measured ('cal', 'rm'). The unit is always mm/s and does not depend on the 'dim' setting. It is intended to prevent mechanical damage as long as the controller does not know the mechanical limits of the axis. (The breaking distance behind the hardware limit switches often is not sufficient to stop the axis under all velocities).
Setting this parameter to higher values may also be used as a workaround at own risk, if executing a cal/rm is not wanted.
Axes which only have one (E0/cal) or do not provide any limit switch (refer to '**swact**' settings) disable the security speed limit after a cal or do not even apply the limit.

Optional read-resolution: As an option to read the parameter with higher precision, the number of required decimal places can be specified with the query "?secvel [0…16 decimal places]". If no precision is defined, the default resolution is 2 decimal places.

Response: Currently used secure velocity in [mm/s]

Examples:
!secvel 100 100 100 => Set maximum possible velocity of X Y Z
!secvel y 14.5 => Set maximum possible velocity of Y to 14.5 mm/s

12.11. cur (Motor Current)

Syntax: !cur or ?cur
Parameter: x, y, z, a or none
0.03 to [maximum current]

Description: This instruction sets or reads the motor current. The maximum current is limited by hardware or additionally by factory settings (ETS) and may be cheched using '**maxcur**' instruction.

Remarks: Please check the motor datasheet first in order not to destroy the motor by overcurrent/overtemperature. Also, if the motor current set too low it can cause the axis to move incorrectly and lead to mechanical damage. At least for open loop systems (without encoder feedback) it is required to ensure the axis can travel under all required velocities and load situations.

Response: Motor current in Ampere (e.g. 1.00)

Examples:

!cur 1.1	set X motor current to 1.1[A]
!cur 1 2	set motor current for X=1[A] and Y=2[A]
!cur z 0.3	set Z motor current to 0.3[A]
?cur	read motor current of all axes
?cur x	read motor current of X axis only

12.12. reduction (Motor Current Reduction Factor)

Syntax: !reduction or ?reduction
Parameter: x, y, z, a or none
0 to 1.00

Description: Motor current reduction factor when idle, used to reduce the dissipated heat from the motor.
When the axis is idle (stopped), the motor current (**cur**) is reduced by this factor.
Floating point numbers from 0 to 1.00 represent 0 to 100% of the motor current. Reduction is disabled when set to 1 (default).

Remarks: The current reduction can be delayed by the '**curdelay**' instruction.
Without a delay, reduction might have a slight impact on vector throughput, as it takes some extra time reduce and increase the current after and ahead of each move instruction. While reducing, the axis might also show slight "waggle", depening on mechanical load.

Response: Reduction factor(s) [0.00 to 1.00]

Examples:

!reduction .3 .7	Set idle current reduction X=0.3*cur[A] and Y=0.7*cur[A]
!reduction 1 1 1	Disable reduction for axes X,Y,Z
!reduction z 0.5	Set Z idle current reduction factor to 0.5*cur[A]
?reduction	Read idle current reduction factor of all axes
?reduction x	Read idle current reduction factor of X axis only (e.g. 1.00)

12.13. curdelay (Delay for Current Reduction)

Syntax: !curdelay or ?curdelay
Parameter: x, y , z, a or none
0 to 65000 [ms]

Description: At the end of each move the axis enters the idle state. If the motor current **reduction factor** is set to a value less than 1.0 this reduction will take effect after the curdelay time.

Remarks: A delay might be necessary in cases of
- long time exposure (to avoid waggle)
- high vector throughput (to avoid reduction between the move)
- heat reduction when not operating (as a "screensaver")

Response: Selected delay time for the current reduction in [ms]

Examples:

!curdelay 100 450	Set delay for motor current reduction X=100[ms] and Y=450[ms]
!curdelay z 15000	Set delay for motor current reduction Z=15 seconds
!curdelay 0 0	Set immediate reduction for X and Y axis
?curdelay	Read motor current reduction delay of all axes
?curdelay x	Read motor current reduction delay of X axis only

12.14. ecomove (EcoMove Current Level)

Syntax: !ecomove or ?ecomove
Parameter: x, y , z, a or none
0 to 70

Description: EcoMove reduces the motor current while the axis travels at constant velocity.
Like "**reduction**" it can be used to greatly reduce the dissipated heat of the motor. But the EcoMove parameter works in a different way: Greater values = greater power saving, which means a eco level value of 0 is 100% current and a eco level of 30 is 70% current.

0 = Full motor current (default)
70 = Maximum power saving level (low motor heating and force)

Response: EcoMove level

Examples:
```
!ecomove 0 0 0 0   (disable ecomove for all axes / 0%)
!ecomove x 25      (reduce X current by 25% when moving)
?ecomove           (return all ecomove levels)
```

12.15. axis (Enable, Disable, Switch Off Axis)

```
Syntax:          !axis or ?axis
Parameter:       x, y, z, a or none
                 -1, 0, 1

Description:     This instruction enables, disables and switches off axes. The
                 currently selected state can also be read.
                 A disabled axis still powers the motor with its current, while
                 a switched off axis loses its torque.

                  1 = enabled
                  0 = disabled
                 -1 = axis power stage off

Response:        Axis enable state

Examples:
!axis 1 1 1 1    enable all axes
!axis 1 0 1 0    disable Y and A axis, enable X and Z
!axis y -1       switch off Y axis: power stage Y off
?axis x          read axis state of X axis only
?axis            read axis state of all axes
```

12.16. axisdir (Axis Direction)

```
Syntax:          !axisdir or ?axisdir
Parameter:       x, y, z, a or none
                 0 or 1

Description:     This instruction sets and reads the travel direction of the
                 axes.
                 Please make sure to first set the desired axis direction
                 before setting the end switch types, polarity etc.!
                 It is not recommended to change direction during operation!

                 0 = Normal   direrction, CAl switch => E0, RM switch => EE
                 1 = Reversed direrction, CAl switch => EE, RM switch => E0

Remarks:         The hardware limit switches CAL/E0,RM/EE will automatically be
                 reassigned when switching the axis direction. Also swact,
                 swpol, swtyp, readsw etc. Exception: The 'swin' function is
                 not affected.
                 Closed loop will be deactivated when changing the diredtion
                 and has to be reenabled by cal or reset/power-on.

Response:        Current axis direction

Examples:
!axisdir 0 1 0 1 Reverse travel directions of Y and A axis
!axisdir z 1     Set reverse travel direction for Z axis
?axisdir         Read axis direction of all axes
?axisdir x       Read axis direction of X axis only
```

12.17. motortable (Motor Correction Table)

Syntax: !motortable or ?motortable
Parameter: x, y , z, a or none
0 or number specified by factory

Description: This instruction adds a motor correction, which can be used to reduce resonances and vibration. The motor has to be measured for the specific application by factory. Then a table number will be assigned and the customer may activate it by setting the corresponding motortable number. Using a wrong motortable will lead to increased noise and position error.

0 = No correction

Response: Currently used motortable(s)

Examples:
!motortable 1 1 2 0 Select motortable 1 for X and Y, 2 for Z and no for A
!motortable x 0 Disable correction for x
?motortable Read the currently used tables for all axes

12.18. usteps (Microstep Resolution)

Syntax: !usteps or ?usteps
Parameter: 360 ... 1638400

Description: This instruction sets the microsteps for one motor revolution, used in axis unit "**dim 0**" (Microsteps). It offers compatibility to application software that is written for e.g. 40000 or 54000 microsteps. One value applies to all axes that have **dim 0** selected.

Remarks: For positioning (moa, mor etc.) in microsteps dim mode 0, the microstep position can also be specified with fractional digits (e.g. !mor 40000 4500 0.5).

Response: Currently used **dim 0** microstepping resolution in [steps/rev]

Examples:
!usteps 40000 Set microstep resolution to 40000/revolution (for dim=0)
?usteps Read the microstep resolution

12.19. resolution (Position Number Format)

Syntax: !resolution or ?resolution
Parameter: 0, 1, ... 6

Description: This instruction sets the resolution of '?pos' and similar position returning instructions for **dim** 1, 2 and 9. It affects the amount of returned decimal places, as listed below.
One value applies to all axes, default = 4 (100nm resolution).

Value	Resolution dim 2,9	Resolution dim 1
0	= 1mm	0.1 µm
1	= 0.1mm	0.1 µm
2	= 0.01mm	0.1 µm
3	= 0.001mm	0.1 µm
4 (default)	= 0.0001mm	0.1 µm
5	= 0.00001mm	0.01 µm
6	= 0.000001mm	0.001 µm

Affected instructions are: ?pos, ?lim, ?maxpos, ?posclr, ?distance, ?twi, ?ctrs, ?ctrdiff, ?caliboffset, ?rmoffset, ?calpos, ?trigd, ?snsa, ?snsp.

Response: Responded decimal places for the 'pos' and other position returning instructions.

Examples:
!resolution 5 Set position read resolution to 10 nm (5 decimal places if mm) e.g. "?pos x" returns 0.00000 in dim 2 and 9, 0.00 in dim 1.
?resolution Read the resolution of

12.20. backlash (Mechanical Backlash Compensation)

Syntax: !backlash or ?backlash
Parameter: x, y, z, a or none
−100.0 ... 100.0 [µm]

Description: This instruction compensates mechanical backlash for each axis. Unit is µm, independent from dim.

0 = Backlash compensation off

Response: Currently used backlash in µm

Examples:
!backlash 12.7 21.3 0 Set backlash for X to 12.7µm, Y=21.3µm and Z=none
!backlash x 0 Disable backlash compensation for X
!backlash x 5 Compensate a backlash of 5µm in X
?backlash Read the backlash compensation value of all axes
?backlash z Read the backlash compensation value of Z axis only

12.21. lock (Select Parameters to Lock)

Syntax: ?lock or !lock
Parameter: 0 to 15, 0 or 1

Description: Select write protection for Nanostep / Tango parameters (lock state).
Either bitwise: !lock [bit number] [0 or 1]
or multi bits : !lock [bit field of 0s and 1s]
After selecting the parameters to lock, these have to be applied to the desired axes by **'lockaxis'**.

Response: Specified lock bit state or entire lock bit field, LSB first.
The bit positions represent the following parameters:

Bit Nr.	Parameter
0:	Pitch
1:	Gear
2:	Cur
3:	MotorSteps
4:	SwPol
5:	SwTyp
6:	SwDir
7:	EncTTL
8:	EncPeriod
9:	AxisDir
10:	MotorTable
11:	BackLash
12:	Anglecorr
13:	CalLrnPos

Example:
```
!lock 111  => Set lock bits 0 1 and 2, leave others unaffected
!lock 2 0  => Clear lock condition for parameter 2 (=current)
!lock 0 1  => Set lock bit for parameter 0 (pitch)
?lock      => Read lock bit field (e.g. "0000000000000000")
?lock 5    => Read lock bit #5 state
```

12.22. lockaxis (Apply the Parameter Lock to Axes)

Syntax: ?lockaxis or !lockaxis
Parameter: x, y , z, a or none

Description: Apply the parameter lock, selected by the **'lock'** instruction, to the specified axes. If the lockbits or lockaxis are zero nothing will be locked.

Response: Axes to which the lock bits are currently applied.

Example:
```
!lockaxis y 1  => Apply lock bits to Y axis
!lockaxis 1 1  => Apply lock bits to X and Y axis
?lockaxis x    => Read if lock bits are applied to the X axis
?lockaxis      => Read all axes (returns e.g. "1 1 0 0")
```

12.23. lockstate (Read all internal Lock States)

Syntax: ?lockstate
Parameter: x, y , z, a or none

Description: Set/read the internal parameter write protection (lock) state caused by the ETS (factory) and user lock/lockaxis settings.
The bit positions represent the following parameters:

Bit Nr.	Parameter
0:	Pitch
1:	Gear
2:	Cur
3:	MotorSteps
4:	SwPol
5:	SwTyp
6:	SwDir
7:	EncTTL
8:	EncPeriod
9:	AxisDir
10:	MotorTable
11:	BackLash
12:	Anglecorr
13:	CalLrnPos

Response: Lock state as 16 bits ASCII string(s), 0s and 1s, LSB first

Example: ?lockstate => Read lock state of all axes
?lockstate x => Lock state of X axis e.g. “1100000000000000”

12.24. stout (Select Status Signal Output)

Syntax: !stout or ?stout
Parameter: 0,1,2,3,4

Description: Makes the state of the Nanostep / Tango Status LED available to
the optional AUX-I/O connector:

0 = Just Status LED, no AUX-I/O used (Standard)
~~1 = AUX-I/O Pin 5 (TAKT_OUT)~~ may not be available!
2 = AUX-I/O Pin 6 (VR_OUT)
3 = AUX-I/O Pin 7 (SHUTTER_OUT)
4 = AUX-I/O Pin 8 (TRIGGER_OUT)

Remarks: To turn off the Status LED, instruction ‘noled’ may be used.

Response: Selected status output mode

Example: !stout 0 => Only use Status LED (default)
?stout => Read status output mode (returns 0,1,2,3 or 4)

12.25. noled (Select Status Signal Output)

Syntax: !noled or ?noled
Parameter: 0 or 1

Description: Set Nanostep / Tango Status LED to “used” or “forced off”. Forcing the LED off may be necessary in low light applications where no external light source is wanted.

0 Normal operation, Status-LED on (default)
1 Status-LED permanently off

Response: Status LED mode

Example: !noled 1 => Force Status-LED permanently off
!noled 0 => Status-LED normal operation (default)
?noled => Read status output mode (returns 0 or 1)

12.26. updelay (Power Up Delay)

Syntax: !updelay or ? updelay
Parameter: -5000 to 5000

Description: Delay time of the Nanostep / Tango controller on power up in [ms].

This parameter is ment for fixing problems of Nanostep / Tango PCI/PCI-E card versions with external power supply or long PCI reset times of the computer mainboard.

Applications:
Use negative values to wait for valid motor voltage (e.g. when using master-slave power switches for the external power supply).
Use positive values to wait a fixed time (e.g. when the mainboard generates a too long reset signal it causes the PCI card to start as a Desktop version. So the COM port is not accessible.)

Positive values: The controller waits for the specified time.
Negative values: The controller waits for valid motor voltage for a maximum of this time or shorter.

Response: Power up delay time in [ms]

Example: !updelay -2000 => Wait max. 2s for valid motor voltage level
!updelay 2500 => Wait 2.5s extra on power up
?updelay => Read the power up delay

13. Limit Switch Instructions (Hardware and Software)

13.1. lim (Software Limits)

Syntax: !lim or ?lim
Parameter: x, y, z, a or none
+maximum position range (unit depends on 'dim')

Description: This instruction sets or reads the movement range limitations. The upper and lower software limits must send together in a single '!lim' instruction. The position unit depends on the 'dim' setting.

Remarks: In **Extended Mode** (extmode = 1) the '?lim' instruction returns the limits as a correctly formatted string, as shown in the example below.

Response: Currently used software limits [lower] [upper]

Examples:

!lim 1000 1000 2000 2000	set the software limits for X and Y
!lim z -500 1700	set the software limits for Z
!lim z -45.37	set the lower software limit of Z
?lim y	read software limits of Y-axis only
?lim	read software limits of all axes
	only recommended in extmode=1, as shown below:

?lim response example for 3 axes in
--> extmode=0: -1000 1000,**[CR]**-1000 1000, -1000 100[CR]
--> extmode=1: -1000 1000 -1000 1000 -1000 100[CR]

13.2. limctr (Enable or Disable Limit Control)

Syntax: !limctr or ?limctr
Parameter: x, y, z, a or none
0 or 1

Description: This instruction enables or disables the limit control or returns the current state of it.

Attention: If limit controls are disabled, the controller doesn't care about limits, which may cause mechanical damage! Limit control is enabled by default from power on.

0 = disabled
1 = enabled (default)

Response: Limit control state

Example:

!limctr y 0	disable Y limit control, Y axis limit switches are ignored
!limctr 1 1 1	enable X, Y and Z limit control
!limctr z 1	enable Z limit control
?limctr a	read limit control state of A axis only
?limctr	read limit control state of all axes

13.3. nosetlimit (Do not set limits by cal/rm)

Syntax: !nosetlimit or ?nosetlimit
Parameter: x, y, z, a or none
0 or 1

Description: Enables or disables the setting of software limits by the calibration (**cal**) and range measure (**rm**) functions.
The default is nosetlimit=0 which means that the software limits are set by the cal/rm moves to these min/max positions.

Response: 0 = set software limits to !cal and !rm positions (default)
1 = do not change software limits after !cal or !rm

Examples:

!nosetlimit 1 1	X and Y axis do not take software limits after !cal and !rm
!nosetlimit y 1	Y axis is does not set software limits of !cal and !rm move
?nosetlimit	read nosetlimit state of all axes
?nosetlimit a	read nosetlimit state of A axis only

13.4. swtyp (Type of Limit Switch)

Syntax: !swtyp or ?swtyp
Parameter: x, y, z, a or none
0 or 1

Description: Set or read the type of the limit switches.
The sequence is [E0] [REF] [EE] for all axes.
The [REF] switch is not used by the Nanostep / Tango controller.

Remarks: When using no axis parameter (x,y,z or a), the 3 values will be used for all axes! To set individual axes, please do this separately, use the axis parameter x,y,z or a.
Please note that the E0 and EE switches are reassigned by a change of the '**axisdir**' instruction.

0 = PNP, which adds a pull-down resistor to the switch input
1 = NPN, which adds a pull-up resistor (default)

Response: Currently selected limit switch type

Examples:

!swtyp z 0 0 1	Set Z axis limit switches E0=PNP, REF(don't care), EE=NPN
?swtyp y	Read switch types of Y axis
!swtyp 1 0 1	Set all! limit switches to NPN type (not recommended)
?swtyp	Not recommended, in extmode=0 returns e.g. 1 1 11 1 11 1 1 in extmode=1 returns e.g. 1 1 1 1 1 1 1 1 1

13.5. swpol (Polarity of Limit Switch)

```
Syntax:          !swpol or ?swpol
Parameter:       x, y, z, a or none
                 0 or 1

Description:     Set or read the polarity of the limit switches.
                 The sequence is [E0] [REF] [EE] for all axes.
                 The REF switch is not used by the Nanostep / Tango controller.
                 Important: When using no axis parameter (x,y,z or a), the 3
                 values will be used for all axes! To set individual axes,
                 please do this separately, use the axis parameter x,y,z or a.
                 Please note that the E0 and EE switch are reassigned by the
                 'axisdir' instruction.

                 0 = switch has active low signal
                 1 = switch has active high signal

Response:        Polarity of the limit switches

Examples:
!swpol y 1 1 1   set polarity of Y limit switches (E0 REF EE) to positive edge
!swpol z 0 0 0   set polarity of Y limit switches (E0 REF EE) to negative edge
!swpol 1 0 1     set polarity of limit switches (E0 REF EE) for all axes
?swpol a         read limit switch polarity of the A axis
```

13.6. swdir (swap assignment of cal and rm switch)

```
Syntax:          !swdir or ?swdir
Parameter:       x, y, z, a or none
                 0 or 1

Description:     Swap the cal(E0) and rm(EE) switch assignment.

                 0 = switches are not swapped (default)
                 1 = switches are swapped

                 In opposite to the axisdir instruction, which swaps motor
                 direction and endswitch assignment, swdir only swaps the
                 switches E0<->EE without changing the axis direction.
                 This may become necessary due to wiring of the axis and
                 depends on the axis hardware. It is independend of axisdir,
                 which works with and without a swapped swdir.

Attention:       swdir should only be used to compensate different wiring of
                 the stage endswitches. Swapping the switches to
                 the wrong assignment may result in mechanical damage!

Response:        Current state of endswith assignment(s)

Examples:
!swdir 1 1 0     Swap E0<->EE switch assignment in X and Y, not in Z
!swdir x 1       Swap E0<->EE switch assignment in X (E0 switch is now EE etc.)
?swdir           Read switch assignment of all axes
?swdir z         Read switch assignment of Z axis only
```

13.7. swact (enable or disable limit switches)

Syntax: !swact or ?swact
Parameter: x, y, z, a or none
0 or 1

Description: This instruction enables or disables the limit switches.
The sequence is always:

E0 REF EE

0 = switch is inactive (actuation state is ignored)
1 = switch is active

The REF switch is not used by the Nanostep / Tango controller.
Disabling limit switches may damage the hardware.
When using no axis parameter, the 3 values will be used for all axes! To set individual axes please do this separately, use the axis parameter x, y, z or a.
Inactive switches always return a non actuated state when using ‘?readsw’, while the ‘swin’ instruction still returns the switches TTL logic level.
Please note that the hardware E0 and EE switches are reassigned by the ‘**axisdir**’ instruction.

Remarks: If all switches of an axis are set to inactive, ‘secvel’ will nor be applied (no velocity limitation at all). If EE (rm) switch is set to inactive, the secvel limitation will be released after the cal. If both switches E0+EE are activated, cal+rm must be executed in order to release the secure velocity.

Response: Limit switch enable states [E0] [REF] [EE] (e.g. 1 0 1)

Examples:
!swact 1 0 1 Enable cal and rm limit switches for all axes (REF disabled)
!swact z 1 0 1 Set Z limit switches E0=enabled REF=disabled EE=enabled
?swact a Read limit switches enable state of A axis only

13.8. readsw (Read Status of Limit Switches)

```
Syntax:          ?readsw or readsw
Parameter:       none

Description:     Readsw returns the actuation state of the limit switch (while
                 swin returns the signal level). Also readsw exchanges the E0
                 and EE switch assignment (cal direction is always E0)
                 depending on 'axisdir'. Disabled switches (swact) are read as
                 0.

                 0 = limit switch is currently not actuated or disabled
                 1 = limit switch is currently actuated (axis is in switch)

                 Please note that the switch state is only valid when the
                 swtyp, swpol parameters are set correctly and the switch is
                 activated by swact.

                 Sequence of the 12 characters is:
                 Axis:    X   Y   Z   A   X    Y    Z    A    X   Y   Z   A
                 Switch: [E0][E0][E0][E0][Ref][Ref][Ref][Ref][EE][EE][EE][EE]

                 E0  = lower limit switch (!cal instruction)
                 Ref = Reference switch
                 EE  = upper limit switch (!rm instruction)

Response:        Actuation state of limit switches as 12 character ASCII string

Examples:        readsw => 000000001000
                 (read all limit switch actuation states, EE of X is actuated)
```

13.9. swin (Read Limit Switch Input Level)

```
Syntax:          ?swin or swin
Parameter:       none or 0...7

Description:     This instruction reads the limit switch signal directly.
                 The response is a string of 8 characters, either 0 or 1.

                 0 = limit switch input signal is TTL low
                 1 = limit switch input signal is TTL high

                 In opposite to the "readsw" instruction, swin reflects the
                 TTL input levels. Also disabled switches are represented with
                 their current TTL input signal level. Swin is not affected by
                 axisdir setting (does not exchange E0 and EE switches).
                 The Ref signals are not used.

                 Sequence of the 8 characters is:
                 Axis:    X       Y       Z       A
                 Switch: [E0][EE][E0][EE][E0][EE][E0][EE]
                 Index :  0   1   2   3   4   5   6   7
                 E0  = lower limit switch (!cal)
                 EE  = upper limit switch (!rm)

Response:        Limit switch input TTL level as 1 or 8 ASCII characters

Examples:        swin   => 11111111 (read all 8 limit switch signal levels)
                 swin 1 => 1        (read EE of X Axis signal level)
```

13.10. statuslimit (Limit Status)

```
Syntax:           ?statuslimit or statuslimit
Parameter:        none

Description:      Status of the known limits (hardware and software).

            They are arranged in 3 groups. Character string positions are:
             0 …  3: Group 1 => cal state of axis 0-3 (x,y,z,a)
             4 …  7: Group 2 => rm  state of axis 0-3 (x,y,z,a)
             8 … 11: Group 3 => lower software limit state of axis 0-3 (x,y,z,a)
            12 … 15: Group 4 => upper software limit state of axis 0-3 (x,y,z,a)

            The characters represent the state with 4 possible characters:
            - => limit not set/modified since power on
            A => axis is calibrated (!cal)
            D => axis is range measured (!rm)
            L => software limit has been modified by (!lim)

Response:         ASCII string of 16 characters

Example:          Assume '?statuslimit' returns the string "AA-A---D-LL-L--L"

                  This means in detail:

                  [ 0]  A -> X-axis is calibrated
                  [ 1]  A -> Y-axis is calibrated
                  [ 2]  - -> Z-axis is not calibrated
                  [ 3]  A -> A-axis is calibrated
                  [ 4]  - -> X-axis is not range measured
                  [ 5]  - -> Y-axis is not range measured
                  [ 6]  - -> Z-axis is not range measured
                  [ 7]  D -> A-axis is range measured
                  [ 8]  - -> X-axis lower software limit is not modified
                  [ 9]  L -> Y-axis lower software limit is modified
                  [10]  L -> Z-axis lower software limit is modified
                  [11]  - -> A-axis lower software limit is not modified
                  [12]  L -> X-axis upper software limit is modified
                  [13]  - -> Y-axis upper software limit is not modified
                  [14]  - -> Z-axis upper software limit is not modified
                  [15]  L -> A-axis upper software limit is modified
```

14. Calibration and Range Measure Instructions

After power on or '!reset' of the controller, a calibration (instruction **!cal**) followed by a range measure (instruction **!rm**) should be executed in order to set the axis origin and hardware position limits.
From then on the controller will stop the axes automatically at the end of the available positioning range. It also disables the secure travel speed limitation of '**secvel**', which else is applied to protect the axes from possible damage.
The cal/rm instructions set the limits close to the limit switch positions. An additional position offset for the these limits can be specified with the instructions !caliboffset and !rmoffset.
Long axes and/or slow velocities may exceed the default calibration timeout of 40 seconds. Therefore the timeout can be set to the desired value by **caltimeout**.
Please also refer to the optional **extmode** enhancements and **calmode** options for calibration.

14.1. cal (Perform Calibration to lower Limit Switch)

Syntax: !cal or cal
Parameter: x, y, z, a or none

Description: This instruction moves either the specified or all axes towards lower positions until the limitswitch E0 is detected. If the corresponding switch is disabled (swact), cal will not be performed.
The behavior of CAL depends on the setting of '**extmode**'.

Extmode=0 (mostly the default setting):
- CAL travels towards switch with the axis velocity '**vel**'
- CAL travels out of switch with '**calbspeed**'

Extmode=1:
- CAL travels towards switch with '**calvel**' parameter 1
- CAL travels out of switch with '**calvel**' parameter 2

The movement stops slightly ahead of the position where the switch was released. If required this travel distance can be increased by specifying a '**caliboffset**'.

Depending on the '**calmode**' setting this position is used as origin (position 0) and if 'nosetlimit' is set to 0 (default) also as the new "lower software limit".

Remarks: The calibration status can be read by checking 'statuslimit'. Highest repeatability (in combination with MR encoders only) can be achieved by teaching a precise 'callrn' position.

Response: **Autostatus** dependent, similar to !moa, !mor etc. but instead of the '@' the axis status return string contains an
'A' after a successful calibration or
'E' if an error occurred (cal was unsuccessful)
'T' if a timeout occurred (cal was unsuccessful)
'-' the axis is not present

Examples:
!cal execute a calibration for all enabled axes => "AAA-."
cal y execute a calibration for Y axis => "@A@-."

This sequence calibrates the X and Z axis => "A@A-."

```
“!axis 1 0 1”
”!cal”
”!axis 1 1 1”
```

14.2. rm (Perform Range Measure to upper Limit Switch)

Syntax: !rm or rm
Parameter: x, y, z, a or none

Description: This instruction moves either the specified or all axes towards higher positions until the limitswitch EE is detected. If the corresponding switch is disabled (swact), rm will not be performed.

The behavior of RM depends on the setting of ‘**extmode**’.

Extmode=0 (mostly the default setting):

- RM travels towards switch with the axis velocity ‘**vel**’
- RM travels out of switch with ‘**calbspeed**’

Extmode=1:

- RM travels towards switch with ‘**rmvel**’ parameter 1
- RM travels out of switch with ‘**rmvel**’ parameter 2

The movement stops slightly under the position where the switch was released. If required this travel distance can be increased by specifying a ‘**rmoffset**’.

Depending on ‘nosetlimit’ (=0, default) also as the new “upper software limit” is set.

Remarks: The rangemeasure status can be read by checking ‘statuslimit’.

Response: **Autostatus** dependent, similar to !moa, !mor etc. but instead of the ‘@’ the axis status return string contains an
‘**D**’ after a successful rangemeasure or
‘E’ if an error occurred (cal was unsuccessful)
‘T’ if a timeout occurred (cal was unsuccessful)
‘-’ the axis is not present

Examples:

!rm	execute a range measure for all enabled axes => “DDD-.”
rm y	execute a range measure for Y axis => “@D@-.”

Or the sequence
“!axis 1 0 1”
”!rm”
”!axis 1 1 1”
range measure the X and Z axis, while Y is not used => “D@D-.”

14.3. vrm (Virtual Range Measure)

Syntax: !vrm or vrm
Parameter: x, y, z, a or none
Axis length(s) in user dim

Description: Can replace the need of a rm move, by just defining the axis length without axis travel (time saving).

Same as with a rm instruction the
- SecVel is released
- corresponding statuslimit 'E' entry is set
- hardware limit is set

Vrm requires that a !cal was performed on the axis.
Vrm does not return the @@@ autostatus reply.

Remarks: Axes with MR encoders (nanoScale) should always perform a true Rm for high accuracy measurement.
Also, specifying a wrong axis length can cause mechanical damage.

Check ?**err** response or **statuslimit** 'E' entries to make sure the parameters were accepted.

If axes are not calibrated the vrm function causes error 2.

Response: None

Examples:
vrm 75 50 virtual range measure (define axis lengths of X=75, Y=50)
vrm y 150 virtual range measure for Y axis (define Y=150)

Sequence example:
```
cal x
cal y
cal z
?statuslimit    => "AAA----------"
vrm 300 300 20
?statuslimit    => "AAA-DDD---------"

cal x
cal y
!moa 10 10
!pos 0 0        (the lower limit is now at position -10 -10)
vrm 300 300     (the upper limit is set to 290 290)
```

14.4. calmode (Closed Loop/Calibration Behavior)

Syntax: !calmode or ?calmode
Parameter: x, y, z, a or none
0, 1 or 2

Description: This instruction reads or sets the closed loop behavior on power-up and also affects the calibration behavior:

0 = Cal instruction sets the zero position (default setting)
Closed loop enabled after cal move

1 = the power-up position remains the zero position even after calibration
Closed loop is enabled from power-up

2 = Cal instruction sets the zero position
Closed loop is enabled from power-up

Remarks: For activating the closed loop, the '**encmask**' of the corresponding axes must be set to one. If encmask is not set or no encoder is present, the calmode only affects the axis zero position behavior.

Response: Calmode of the axes

Examples:

!calmode 0 0 0	Calmode behavior of axes X,Y,Z set to default operation
!calmode z 2	Set Z axis to enter closed loop instantly after power-up
?calmode	Read calmode of all axes
?calmode y	Read calmode of Y axis only

14.5. carequired (Calibration Required)

Syntax: !calrequired or ?calrequired
Parameter: x, y, z, a or none
0 or 1

Description: The calibration required mode offers a mechanism to avoid axis travel until the !cal instruction is executed. It can be set for each axis individually.

0 = Axes can move even without !cal (default)
1 = Axes are halted as long as !cal was not executed (

Response: Calrequired setting of the axes

Examples:

!calrequired 0 0 0	No cal required to enable X,Y,Z axis move (default)
!calrequired z 1	Cal required to enable axis move in Z
?calrequired	Read calrequired mode of all axes
?calrequired y	Read calrequired mode of Y axis only

14.6. caltimeout (Calibration Timeout)

```
Syntax:           !caltimeout or ?caltimeout
Parameter:        x, y, z, a or none
                  1 to 120 (seconds, as integer)

Description:      This instruction specifies the timeout for calibration (cal)
                  and range measure (rm) instructions. It can be set for each
                  axis individually, depending on axis length and velocities.
                  The default value is 40 or 60 seconds.

Remarks:          For long axes (over 350mm) the default timeout of 40s is
                  insufficient and must be increased, as a typical cal/rm
                  travel velocity is 10mm/s.

Response:         Calibration+RangeMeasure timeout in seconds

Examples:
!caltimeout 60 60 60    set the cal/rm timeout for X,Y,Z to 60 seconds
!caltimeout x 40        set the cal/rm timeout for X to 40 seconds
?caltimeout             read timeout of all axes
?caltimeout z           read timeout of Z axis only
```

14.7. caliboffset (Calibration Offset)

Syntax: !caliboffset or ?caliboffset
Parameter: x, y, z, a or none
Position (0.0 ... 100mm, depends on 'dim')

Description: This instruction specifies a calibration position offset. When executing a 'cal' instruction, the axis travels this extra distance away from the limit switch E0 and sets the origin (axis zero position) there.
The unit depends on the current 'dim' settings. Valid position range is "0.0 to 100mm equivalent". The default value is 0.

Response: Calibration Cal switch position offset

Examples:

```
!caliboffset 10 5.5 0.1 set the calibration offset for X, Y and Z axis
!caliboffset x 0.05     set the calibration offset for X axis to 0.05
?caliboffset            read the calibration offset of all axes
?caliboffset y          read the calibration offset of Y axis only
```

14.8. rmoffset (Range Measure Position Offset)

Syntax: !rmoffset or ?rmoffset
Parameter: x, y, z, a or none
Position (0.0 ... 100mm, depends on 'dim')

Description: Similar to caliboffset, this instruction specifies an extra position offset for the 'rm' instruction. The axis travels this extra distance away from the upper limit switch EE and sets upper limit position there.
The unit depends on the current 'dim' settings. Valid position range is "0.0 to 100mm equivalent". The default value is 0.

Response: Range Measure RM switch position offset

Examples:

```
!rmoffset 1 1 1   set the range measure offset to 1 (mm at dim 2) for X, Y and Z
!rmoffset z 0.1   set the range measure offset to 0.1 (mm at dim 2) for Z only
?rmoffset         read range measure position offset of all axes
?rmoffset z       read range measure position offset of Z axis only
```

14.9. caldir (Calibration Direction)

Syntax: !caldir or ?caldir
Parameter: x, y, z, a or none
0 or 1

Description: This instruction set the calibration direction to either positive or negative positions. Default is negative direction. If set to positive(=1), the upper software limit is set. This instruction is not possible for systems with encoders.

Response: 0 = cal move to negative direction
1 = cal move to positive direction

Examples:

```
?caldir           read calibration directions of all axes
!caldir y 1       set Y axis calibration direction to positive
!caldir 0 0 1     set Z axis calibration direction to negative
```

14.10. calbspeed (Calibration Speed for Retraction)

Syntax: !calbspeed or ?calbspeed
Parameter: x, y, z, a or -1
0.1 to 8000 [*0.01 revolutions/s]

Description: **(Available in EXTMODE=0 only, else use calvel/rmvel)**
Set or read the cal/rm calibration speed which is used for traveling out of the limit switches E0 and EE.

Remarks: RESTRICTIONS APPLY DUE TO BACKWARDCOMPATIBILITY. See examples. Setting the calbspeed without specifying an axis will set all axes to this one value. It is recommended to access axes individually. Refer to examples below.
Calbspeed is only available in **extmode=0**. For improved behavior and flexibility please refer to the **calvel**, **rmvel** instructions, which become available with **extmode=1** and replace the calbspeed and vel.

Response: Currently used calibration back speed [in 1/100 motor rev/s]

Examples:

!calbspeed 50 50	*ILLEGAL INSTRUCTION!*
!calbspeed 15	*COMPATIBILITY RESTRICTIONS!* 0.15 [revolutions/s] for all axes!
?calbspeed	*COMPATIBILITY RESTRICTIONS!* returns one parameter!
?calbspeed -1	read the the limit switch retraction speed of all axes
!calbspeed z 20	set the limit switch retraction speed for Z only (recommended)
?calbspeed x	read the limit switch retraction speed for X (recommended)

14.11. calrefspeed (Reference Signal Calibration Speed)

Syntax: !calrefspeed or ?calrefspeed
Parameter: x, y, z, a or -1
0.1 to 8000 [*0.01 revolution/s]

Description: Reference mark calibration speed. This speed is used when searching the encoder reference mark. The default value is 32 (0.32 rev/s). There is only one value for all axes.

Remarks: RESTRICTIONS APPLY DUE TO BACKWARDCOMPATIBILITY. See examples.
It is recommended to use the new instruction 'encrefvel'.

Response: Currently used calrefspeed [in 1/100 motor rev/s]

Examples:

!calrefspeed 5 5	*ILLEGAL INSTRUCTION!*
!calrefspeed 15	*COMPATIBILITY RESTRICTIONS!* 0.15 [revolutions/s] for all axes!
?calrefspeed	*COMPATIBILITY RESTRICTIONS!* returns one parameter!
?calrefspeed -1	read the the referencing speed of all axes
!calrefspeed z 20	set the referencing speed for Z only (recommended)
?calrefspeed x	read the referencing speed for X (recommended)

14.12. encrefvel (Encoder Ref Signal Calibration Velocity)

```
Syntax:           !encrefvel or ? encrefvel
Parameter:        x, y, z, a or none
                  0.000001 to 3000 [rev/s] (or [mm/s] if dim=9)

Description:      Replaces the !calrefspeed instruction.
                  Set or read the velocity, at which the reference mark search
                  is performed (during !cal, after releasing the limit switch).

Response:         Currently used encrefvel in [rev/s] or [mm/s] when dim=9

Examples:
!encrefvel 5 5 5  Set encoder reference mark search velocity to 5 (mm/s @ dim=9)
!encrefvel z 0.5  Set encoder reference mark search velocity for Z axis to 0.5
?encrefvel        Read velocities of all axes
?encrefvel y      Read velocities of Y axis only
```

14.13. refdir (Direction for Searching Reference Signal)

```
Syntax:           !refdir or ?refdir
Parameter:        x, y , z, a or none
                  0 or 1

Description:      DUMMY INSTRUCTION.
                  Specifies or reads the direction in which to search the
                  reference switch [REF]. This switch is not available with
                  Nanostep / Tango controllers.

Response:         0 = search in negative direction (default)
                  1 = search in positive direction

Examples:
!refdir y 1       set the Y-axis reference search to positive direction
!refdir 1 1 0     set the reference search direction of X, Y and Z axis
?refdir           read reference search directions of all axes
?refdir x         read reference search direction of X axis only
```

14.14. calpos (Calibration Position)

Syntax: !calpos or ?calpos
Parameter: x, y, z, a or none
position value (unit depends on ‘dim’)

Description: Used, in combination with an encoder, to measure calibration position accuracy (repeatability of the origin).
During calibration the encoder signal period, where the limit switch E0 was released and the origin (pos=0) was set, is stored. This position value within an encoder period can be read with ‘?calpos’.
The position may also be set to another value. The unit depends on the setting of ‘dim’. Valid range is 0 to 100mm equivalent.

Remarks: This instruction is used for systems with encoders only.

Response: A position within the range of one encoder signal period

Examples:

?calpos y	read calibration position of Y axis (e.g. returns 0.0000)
?calpos	read calibration position of all axes
!calpos 0 0 0	set calibration positions to zero (X, Y and Z)
!calpos y 0	set calibration position of Y axis to zero

14.15. calvel (Calibration Velocities for CAL Instruction)

Syntax: !calvel or ?calvel
Parameter: x, y, z, a or none
two velocities >0.0 (in [motor rev/s] or [mm/s] if dim=9)

Description: **This instruction is accessible in EXTMODE=1 only.**
If 'extmode' is set to 1, this instruction replaces the 'calbspeed' and 'vel' parameters for the calibration (!cal) function:

Parameter 1 = speed towards cal limit switch (find)
Parameter 2 = speed out of cal limit switch (release)

The unit is [motor rev/s] for 'dim' settings 0 to 8, and [mm/s] fro dim=9.

The travel speed towards the limit switch should not be more than 10mm/s to prevent mechanical damage (axis must stop after sudden limit switch event).
The travel speed out of (releasing) the limit switch should be low for achieving high position accuracy, e.g. 0.5mm/s

Response: Two velocities (towards and out of endswitch) per axis

Examples:

!calvel x 10 0.5	Cal in X moves towards endswitch with velocity 10 [rev/s] or [mm/s], depending on dim and out of the endswitch with velocity 0.5
?calvel	read cal velocities of all axes
?calvel y	read cal velocities of Y axis only (e.g. returns 10.000 0.500)

14.16. rmvel (Range Measure Velocities for RM Instruction)

Syntax: !rmvel or ?rmvel
Parameter: x, y, z, a or none
two velocities >0.0 (in [motor rev/s] or [mm/s] if dim=9)

Description: **This instruction is accessible in EXTMODE=1 only.**
If 'extmode' is set to 1, this instruction replaces the 'calbspeed' and 'vel' parameters for the range measure (!rm) function:

Parameter 1 = speed towards rm limit switch (find)
Parameter 2 = speed out of rm limit switch (release)

The unit is [motor rev/s] for 'dim' settings 0 to 8, and [mm/s] fro dim=9.

The travel speed towards the limit switch should not be more than 10mm/s to prevent mechanical damage (axis must stop after sudden limit switch event).
The travel speed out of (releasing) the limit switch should be low for achieving high position accuracy, e.g. 0.5mm/s

Response: Two velocities (towards and out of endswitch) per axis

Examples:

!calvel x 10 0.5	Rm in X moves towards endswitch with velocity 10 [rev/s] or [mm/s], depending on dim and out of the endswitch with velocity 0.5
?calvel	read rm velocities of all axes
?calvel y	read rm velocities of Y axis only (e.g. returns 10.000 0.500)

14.17. autopitch (Measure Pitch after CAL Instruction)

Syntax: !autopitch or ?autopitch
Parameter: x, y, z, a or none
0 or 1

Description: Measures and sets the spindle pitch each time when executing a cal instruction.
Remarks: Only works if encoders are present.
Not recommended for spindles and precision drives.

Response: Autopitch enabled (1) or disabled (0, default)

Examples:

!autopitch 1 1 0	Measure and readjust pitch after each cal instruction X and Y
!autopitch y 1	Measure and readjust pitch after each cal instruction in Y
?autopitch	read autopitch setting of all axes
?autopitch x	read autopitch setting of X axis

Pitch measuring sequence example:
"!autopitch x 1"
"!cal x"
[wait for reply]
"!autopitch x 0"
"?pitch x"
"!save"

15. Move Instructions

Move instructions command the Nanostep / Tango to move axes to certain positions or to travel at a constant, specified velocity. Positioning can be executed for individual axes or combined as a vector move.

Positioning (moa, mor, m, moc) is based on the velocity (vel) and acceleration (accel,accelfunc) settings. If executed as a vector of 2 or more axes, the Nanostep / Tango automatically selects the "leading" axis and adjusts the other axes in a way that none of their velocity and acceleration parameters is exceeded.

Moa and mor are similar instructions. Moa travels based on absolute coordinates, defined by the axis origin or the overwritten "pos", while mor travels relative to the current position.

The "m" instruction can be used to achieve high vector throughput with little communication overhead (often combinmed with autostatus=3). The relative distances have to be preset – either the last "mor" or a "distance" instruction.

A special case of positioning is available with the !go instruction. It does not move as a vector, here each axis travels at its own velocity and accel settings. Also it only provides linear acceleration (accelfunc does not apply).
The advantage of the !go instruction is that it can be overwritten at any time with no need to abort the currently executed move. It will smoothly change directions. Target applications are e.g. focusing via a slidebar or tracking a mouse cursor position.

The third option for axis travel is "speed move". Here not positions but velocities are specified. The addressed axes travel at this velocities until stopped, aborted or reaching a position limit. Like !go, the speed instruction is also not executed as a vector and does not use the accelfunc. Speed requires the "joystick" to be enabled.

Remarks on relative positioning:
Due to internal resolution a sequence of many consecutive relative moves may lead to (minor) absolute position deviation. Executing an absolute move at times is recommended.
Also, if HDI is enabled, minor changes in position may occur due to the connected device (Joystick, ErgoDrive). Which can also accumulate position error when only using relative moves. It is recommended to deactivate the HDI when using relative moves (by instructions **joy** or **joydir**).

15.1. moa (Move Absolute)

Syntax: !moa or moa
Parameter: x, y, z, a or none
position values within ±maxpos

Description: This instruction commands one or more axes to the specified position(s). The position unit depends on **dim** settings.

Response: Depends on **autostatus** settings, which per default is set to 1. Each commanded (and enabled) axis responses either '@' after successfully completing the move, or 'E' if an error occurred. For further information on response options, please refer to **autostatus** and **statusaxis**.

Examples:

moa 10 0 20	axes X,Y,Z travel to the specified positions (vector move)
moa 10 0.5	axes X and Y travel to the specified positions (vector move)
moa x 10.2	X-axis travels to position (e.g. 10.2mm if dim=2)
moa 10.2	same as "moa x 10.2"
moa y 34.5	Y-axis travels to position (e.g. 34.5mm if dim=2)

15.2. mor (Move Relative)

Syntax: !mor or mor
Parameter: x, y, z, a or none
distance values within ±maxpos

Description: This instruction commands one or more axes relative to the current position. The position unit depends on **dim** settings.

Response: Depends on **autostatus** settings, which per default is set to 1. Each commanded (and enabled) axis responses either '@' after successfully completing the move, or 'E' if an error occurred. For further information on response options, please refer to **autostatus** and **statusaxis**.

Examples:

mor 10 0 -20	axes X,Y,Z travel the specified distances (vector move)
mor 10 0.5	axes X and Y travel the specified distances (vector move)
mor x 10.2	X-axis travels the specified distance (e.g. 10.2mm if dim=2)
mor 10.2	same as "mor x 10.2"
mor y -34.5	Y-axis travels e.g. (if dim=2) 34.5mm backwards

15.3. m (Move Relative Shortcut)

Syntax: !m or m
Parameter: none

Description: The instruction is a shortcut (abbreviation) of mor. It is useful to speed up communication especially for consecutive identical vectors. The vector is taken from the preceding !mor or !distance instruction. The instruction will move all enabled axes if their distance is not zero.

Response: Depends on state of autostatus, recommended is mode 3.

Example: Positioning sequence involving moa,mor,m

```
!moa 1 2 3 4      will move to 1 2 3 4
!mor 1 1 1 1      will move to 2 3 4 5    (mor sets distance)
m                 will move to 3 4 5 6
!distance 0 2 0 0                         (specify distance)
m                 will move to 3 6 5 6
m                 will move to 3 8 5 6
```

15.4. distance (Distance for m)

Syntax: !distance or ?distance
Parameter: x, y, z, a or none
Distance (within +-maxpos)

Description: This instruction sets the travel distance for !m instructions. The unit depends on the ‘**dim**’ settings.

Remarks: The distance value is also set by each ‘!mor’ instruction. Distances must be defined for all axes, axes that shall not move have to be set to distance = 0.

Response: Currently used value for distance (unit depends on ‘**dim**’)

Examples:

```
?distance          read distance values of all axes
?distance z        read distance value of Z axis only
!distance 10 20 0  set X and Y distance
!distance 1 2 0.5  set X, Y and Z distance
!distance y 20.2   set Y distance only, other axes keep their distance values
```

15.5. moc (Move to Center)

Syntax: !moc or moc
Parameter: x, y, z, a or none

Description: The specified or all enabled axes travel to the center position between their lower and upper software limit. It is recommended to first execute the !cal and !rm instructions.

Response: Depending on ‘autostatus’ settings, each successful centered axis responds with “@”.

Examples:

```
moc               all axes travel to their center position
moc y             Y-axis travels to the center position
```

15.6. go (Go To Position)

Syntax: !go or go
Parameter: x, y, z, a or none
position values within ±maxpos

Description: Used for position tracking applications.
Similar to the 'moa' instruction, 'go' executes a move of one or more axes to an absolute position.

The differences to absolut move instructions are:

- Go can be overwritten anytime, also when moving, by another go position (without the need to abort or stop it first)
- Go is no vector move, each axis moves at its own velocity '**vel**' and acceleration
- It supports only linear acceleration
- No autostatus reply on completion (polling of '**statusaxis**' required)

The unit of the position values depends on **dim**.

Remarks: In order to check for a completed go move, please poll the '**statusaxis**' state, which should not be 'M' then.

Response: None.

Examples:

go 10.7 14	axes X and Y travel to the specified positions (no vector)
go x 10.2	the X-axis travels to position 10.2 ([mm] assume dim=2)
go 10.2	same as "go x 10.2"
go 10.1 -0.5 0	axes X, Y, Z travel to the specified positions (no vector)

15.7. speed (Speed Move)

Syntax: !speed or ?speed
Parameter: x, y, z, a or none
+100.0 [rev/s] or [mm/s] in dim=9 only

Description: Start axes to travel at the specified velocities. Travel can be stopped by setting the speed to zero. Or when reaching a soft- or hardware limit.
The speed instruction is also called "digital Joystick", therefore it only applies when joystick is enabled: **joy**, **joydir**

Remarks: For endless rotation please refer to '!**zero**' and **modulomode**=1.

Response: Currently executed speed in [rev/s], or [mm/s] if dim=9
There is no autostatus reply.

Examples:

!speed 33 0.01	start speed move for X= 33[rev/s] and Y= 0.01[rev/s]
!speed 10	start speed move for X-axis to 10[revolutions/s]
!speed y 0.001	start speed move for Y-axis
!speed 0 0 0 0	stop speed move for all axes
!speed 0	stop speed move for X-axis

```
!speed z 0          stop speed move for Z-axis
?speed              read the currently executed speed of all axes
?speed z            read the currently executed speed of Z-axis only
```

15.8. a (Abort the Current Move)

Syntax: !a or a
Parameter: x, y, z, a or none

Description: This instruction stops either all axes or the specified axis and sets them into position reached state.
Sending a “Ctrl+C” (hex 0x03) will stop all axes as well.

Remarks: Abort might fail in special cases of closed loop errors.
In such case closed loop has to be deactivated as well.

Response: Depends on the instruction being executed (moa,speed,go etc.) and **autostatus**. If a move was aborted in autostatus=1 (default) and all axes stopped, each axis responds an ‚@’.

Example:
```
a     (abort move of all axes)
a y   (abort move of Y axis only)
```

15.9. delay (Set the Delay Time for Consecutive Moves)

Syntax: ?delay or !delay
Parameter: 0 to 10000 [ms]

Description: This instruction will insert a delay time before executing a move (delayed start). There is only one value for all axes.
Applies to: moa,mor,moc,m

Response: Delay time in [ms]

Examples:

!delay 500	Delay the start of a move instruction by 0.5 seconds
?delay	Read the delay time

15.10. pause (Set the Pause after Position Reached)

Syntax: ?pause or !pause
Parameter: 0 to 10000 [ms]

Description: Complementary to “delay”, this instruction adds a pause time after the axes have reached their target positions. In autostatus=1 mode the “@@@-.” response is delayed by this time. It may be used to insert an automatic settling time after moa,mor,moc or m. There is only one value for all axes.

Response: Pause time in [ms]

Examples:

!pause 10	Delay the autostatus response of a move by 10 milliseconds
?pause	Read the pause time

15.11. pos (Read or Set Position)

Syntax: !pos or ?pos
Parameter: x, y, z, a or none
Position (within +-maxpos)

Description: This instruction either reads or sets the axis position.
If set, this defines a new absolute position of the axis.
The unit depends on the selected dimension (**dim**).

Remarks: For axes with encoders, the encoder position can be returned by setting its '**encpos**' to 1.

The effect of manipulating positions with "!pos" can be removed by the instruction "posclr".

Response: Axis position(s) (depends on **dim** and enc+encpos state)

Examples:

?pos	Read all axis positions
?pos z	Read Z axis position only
!pos 100 200	Set the current X and Y axis positions
!pos -0.1	Set the current X position to -0.1 (unit depends on dim)
!pos y 2000	Set the current Y position to be 2000 (unit depends on dim)

15.12. posclr (Clear Position Offset)

Syntax: !posclr or ?posclr
Parameter: x, y, z, a or none

Description: Reset or read the position offset to the axis origin, which was added by a !pos instruction.

The absolute position can be redefined by "!pos". In order to return to the original absolute position, clearpos offers reading or clearing of the changes made by !pos.

Response: Position offsets (depending on **dim**)

Examples:

```
!posclr x          (reset X to original position)
!posclr            (reset all positions to original position)
?posclr            (read position offset of all axes)

?pos       => 1.0000 2.0000 3.0000
!pos y 8      (here a position offset of 8-2=6 is added to Y)
?pos       => 1.0000 8.0000 3.0000
?posclr    => 0.0000 6.0000 0.0000
!posclr     (here the !pos set position offsets are removed)
?pos       => 1.0000 2.0000 0.0000
```

15.13. zero (Set Internal Position to Zero)

```
Syntax:          !zero or zero
Parameter:       x, y, z, a or none

Description:     Unlike “!pos 0”, the “!zero” instruction also resets the
                 internal position counter to zero.
                 It has to be used in applications where axes exceed the
                 position limits, e.g. filter wheels (in such case a “!pos 0”
                 instruction is not sufficient).
                 The zero instruction should be executed after completing one
                 or several complete revolutions, before reaching the software
                 limits. So the reference point remains at the same position.

Response:        none.

Examples:
!zero            Set all internal positions to zero
!zero z          Set Z axis position to zero
```

15.14. clearpos (Set Internal Position to Zero)

```
Syntax:          !clearpos or clearpos
Parameter:       x, y, z, a or none

Description:     For compatibility with LStep controllers.
                 Functionality is almost the same as with the ‘zero’
                 instruction.
                 The only difference is that the clearpos instruction
                 is not executed when in closed loop.

Response:        none.

Examples:
!clearpos        Set all internal positions to zero
!clearpos x      Set X axis position to zero
```

16. HDI: Joystick, Tackball and Handwheel Instructions

The HDI (human device interface) provides manual control of the axes.
The velocities are limited by the **secvel** velocity as long as no **cal** and **rm** sequence has been executed. The axis travel will stop at either the hardware limit switches or the adjustable software limits (**lim**).
The velocities are either taken from the current axis velocity **vel** or, if '**extmode**' is enabled as an independent **joyvel**.
The HDI interface tolerates hot plugging of the devices. It is possible to unplug, plug or change the input devices during operation of the controller.
The **keymode** functionality enables selection of different **keyspeed** or **zwtravel** wheel velocities by pressing the function keys of the joystick. Please refer to **keymode** for further informations.
The optional **z-wheel**, found on several devices, can be assigned to any axis. The default assignment is axis 3 (Z) and can be changed by **zwaxis**.

16.1. joy (Generally Enable/Disable HDI)

Syntax: !joy or ?joy
Parameter: 0, 1, 2, 3, 4 or 5

Description: Generally enanble or disable the connected HDI device (joystick, trackball, ErgoDrive etc.)
It is recommended to only use the values 0 or 2.

0 disable HDI device
2 enable HDI device (=default)

Remarks: The '**speed**' instruction also requires joy to be enabled (2).

Response: HDI enable state

Examples:
!joy 0 disable the HDI device (joystick, trackball etc.)
!joy 2 enable the HDI device (default)
?joy read HDI enable state

16.2. joydir (Joystick Direction or Assign Joystick per axis)

Syntax: !joydir or ?joydir
Parameter: x, y, z, a or none
and 0, 1, 2, -1, -2

Description: In addition to the '**joy**' instruction, joydir can be used to enable/disable individual HDI axes and set their directions. It is recommended to use the values 2, 0 or -2 only. The options are:

0 = Disable HDI axis (e.g. joystick deflection is ignored)
1 = Enable HDI axis, no motor current reduction
2 = Enable HDI axis, current reduction supported (default)
-1 = Same as 1, direction reversed
-2 = Same as 2, direction reversed

Remarks: Please also make sure that the joystick function is globally enabled by the '**joy**' instruction.

When using a 4 axis controller with a 3 axis HDI device, the 3rd axis must be assigned to axis 3(=default setting), 4 or both (3 and 4) by enabling/disabling their joydir!

This instruction also enables or disables the '**speed**' move for individual axes, but does not change the speed directions.

Response: HDI directions of the axes or specified axis

Examples:

!joydir 2	enable HDI X-axis in reversed direction
!joydir z 0	disable HDI Z-axis
!joydir 2 2 0 2	set positive direction, allow current reduction, assign the joysticks 3rd axis to the controller A axis instead of Z
?joydir	read HDI enable/direction setting of all axes
?joydir y	read HDI enable/direction setting of Y axis only

16.3. joychangeaxis (Change Joystick X and Y Axis)

Syntax: !joychangeaxis or ?joychangeaxis
Parameter: 0 or 1

Description: Change the assignment of the Joystick X and Y axes.

0 = no change (default)
1 = Joystick X and Y axes changed (X=Y, Y=X)

Remarks: Only for Joystick devices.

Response: Joystick X-Y change setting

Examples:

!joychangeaxis 1	change X and Y axis of the Joystick
?joychangeaxis	read Joystick X,Y change state

16.4. joywindow (Joystick Window)

Syntax: !joywindow or ?joywindow
Parameter: 0 to 100

Description: This instruction sets the center position threshold of the Joystick in digits. A deflection, as long as it is in this window, has no effect. There is only one value for all axes. The default value of +/- 14 should not be reduced, as this may result in slow unwanted creeping of axes even when the joystick is apparently not deflected. Increasing the value will reduce the velocity resolution (available steps).

Response: joywindow [in digits]

Examples:
?joywindow read joystick window
!joywindow 14 set joystick window to +-14

16.5. joyvel (Joystick Velocity)

Syntax: !joyvel or ?joyvel
Parameter: x, y, z, a or none
0.000001 to 200 [revolutions/s] or equiv. [mm/s] if dim=9

Description: **This instruction is accessible in extmode 1 only!**
In extmode=1 this instruction must be used to set the joystick velocities. As the vel instruction then has no influence to the joystick velocity. In normal mode (extmode=0) the joystick velocities are derived from the axis vel settings.

Response: Currently used joystick velocities

Examples:
!joyvel 12.5 20 0.4 Set joystick velocities for 3 axes
!joyspeed z 1 Set joystick velocities for z to 1 [rev/s], (e.g. dim=2) or [mm/s] if dim=9
?joyvel x Read joystick velocity of X-axis

16.6. joyspeed (Joystick Speed Presets for BPZ Device)

Syntax: !joyspeed or ?joyspeed
Parameter: 1, 2 or 3 and
0.000001 to 200 [revolutions/s]

Description: **Only used by a customer designed HDI device** (called BPZ), this instruction sets the joystick speeds for the three speed buttons (Slow, Medium, Fast). Unit is in motor revolutions per second (like 'vel' instruction). While the velocity applies to all axes, each speed button has to be set individually:
1 = Slow Button speed, one parameter for all axes
2 = Medium Button speed, one parameter for all axes
3 = Fast Button speed, one parameter for all axes

Response: Speed currently assigned to the specified button in [rev/s]

Examples:
?joyspeed 1 Read "Slow" joystick button speed
!joyspeed 3 30 Set "fast" joystick button speed to 30 [revolutions/s]

16.7. keymode (Joystick Key Mode)

Syntax: !keymode or ?keymode
Parameter: 0, 1 or 2

Description: Assign keyspeed values to the Joystick buttons. The Joystick can be used with two different velocity settings slow/fast. in keymodes 1,2 'vel' or 'joyvel' instructions have no effect. In such case refer to '**keyspeed**', which will be used then. Please note that other special functions which require Joystick buttons (e.g. **snapshot modes**) should not be used at the same time as keymode.

A) If Joystick toggle mode ('**hdimode**') is selected:

--> F1 toggles XY between the keyspeed values
--> F4 toggles Z keyspeeds (available from firmware 1.56)

B) If '**hdimode**' is not set to toggle mode, the behavior is:

Pressing F1 selects the fast keyspeed values of X and Y axis,
while F4 selects the slow keyspeed values of X and Y axis.

Pressing F2 selects the fast keyspeed value of the Z axis,
while F3 selects the slow keyspeed value of the Z axis.

In case of joysticks with the optional '**z-wheel**', the wheel velocities can be selected by pressing F1, F4, or no key. Please refer to the '**zwtravel**' description.

Recommended Joystick settings are:

2/3 axis Joystick: hdimode 0 or 1 to either toggle velocities by pressing F2/F3, F1/F4 (0) or to toggle by pressing F1 (1).

Joystick with wheel: hdimode 0 to toggle XY by F2,F3 and the wheel with pressing none/F1/F2.

Parameter description:

0 = Normal key functions
1 = X/Y and Z Joystick velocity, initial value: slow [F4,F3]
2 = X/Y and Z Joystick velocity, initial value: fast [F2,F1]

Response: keymode as decimal number

Examples:
!keymode 1 slow preset keymode
?keymode => 0 (in case keymode is disabled)

16.8. keyspeed (Joystick Key Speed Presets)

```
Syntax:           !keyspeed or ?keyspeed
Parameter:        x, y, z, a or none
                  0.000001 to 3000 [mm/s]

Description:      Two Joystick velocities can be set for each axis individually.
                  The first parameter is the slow value and the second parameter
                  is the fast. Unit is always mm/s, independent from 'dim'.
                  In keymode 1 or 2 the X and Y values (slow/fast) are assigned
                  to F4 and F1, while the Z values are assigned to F3/F2.
                  Please also refer to 'keymode'.

Response:         Two floating point values per axis (slow fast)
                  single axis  : => [slow] [fast]
                  multiple axes: => [slow_x] [fast_x] [slow_y] [fast_y] ...

Examples:
?keyspeed x       => 1.00 10.00 (Read X Joystick button velocity)
?keyspeed         => 1.00 10.00 1.00 10.00 0.10 1.00 (Reply of 3 ax. controller)
!keyspeed z 0.1 1 (Set fast Joystick button speed to 0.1 and fast to 1 [mm/s])
!keyspeed 5 20 2 10 0.2 2 (Set 3 axes at once)
```

16.9. joycurve (Joystick Characteristic)

```
Syntax:           !joycurve or ?joycurve
Parameter:        x, y, z, a or none
                  0, 1, 2

Description:      The speed characteristic of Joystick deflection
                  can be independently defined for each axis.

                  0 = Logarithmic (default)
                  1 = Linear
                  2 = Quadratic

Response:         Currently used characteristic

Examples:         !joycurve 0 0 0 => set X,Y,Z axes to logarithmic
                  !joycurve z 1   => set Z axis to linear
                  ?joycurve       => read characteristic of all axes
```

16.10. key (Read HDI Device Key State)

```
Syntax:          ?key or key
Parameter:       none or key number 1, 2, 3, 4

Description:     This instruction reads the state of up to 4 HDI device keys.

                 0 = key is currently released or not available
                 1 = key is currently pressed

Response:        1 or 4 Key states, each either 0 or 1

Examples:        key   => query all keys, returns 4 numbers, e.g. 0 0 0 0
                 key 1 => query only key 1 (e.g. F1 Joystick button)
                 key 3 => query only key 3 (e.g. F3 Joystick button)
```

16.11. keyl (Read HDI Device Latched Key State)

```
Syntax:          ?keyl or !keyl
Parameter:       none or key number 1, 2, 3, 4

Description:     The ?keyl or keyl instruction read the latched state of the
                 specified or all 4 HDI device keys and clears their latched
                 state. The latch state is cleard after reading.
                 The Instruction !keyl clears the latched state of the
                 specified or all keys to zero (0) without reading.

                 0 = key is is/was released since last key or keyl instruction
                 1 = key is is/was pressed since last key or keyl instruction

Response:        1 or 4 Latched key states, each either 0 or 1

Examples:        keyl    => read+clear all 4 keys, returns e.g. 0 1 0 0
                 keyl 1  => read+clear only key 1 (e.g. F1 Joystick button)
                 ?keyl 1 => same as “keyl 1”
                 !keyl 1 => clear latch state of key 1 only (to zero)
                 !keyl   => clear latch state of all 4 keys (to zero)
```

16.12. hwfactor (Handwheel Transmission Factor)

```
Syntax:          !hwfactor or ?hwfactor
Parameter:       x, y, z, a or none
                 and -200.0 to 200.0

Description:     The handwheel transmission factor defines the axis travel
                 distance in millimeter per handwheel knob revolution, which is
                 a floating point number between -200.0 and +200.0.
                 Negative factors reverse the travel direction (as joydir -2).
                 Higher factors result in a more coarse resolution, a typical
                 handwheel provides about 100000 steps per revolution.

Response:        Currently used handwheel factor(s)

Examples:
!hwfactor 14 14  => One knob revolution in X or Y results in 14mm axis travel
!hwfactor x 100  => One knob revolution in X results in 100mm travel
?hwfactor        => Read transmission factor of all axes
```

16.13. hwfactorb (Alternate Handwheel Factor)

```
Syntax:          !hwfactorb or ?hwfactorb
Parameter:       x, y, z, a or none
                 and -200.0 to 200.0

Description:     Similar to 'hwfactor', this instruction gives access to the
                 alternate (second) parameter for travel distance per knob
                 revolution. Which is available with the ErgoDrive.
                 Negative factors reverse the travel direction.

Response:        Currently used alternate handwheel factor(s)

Examples:
!hwfactorb 26.6 26.6  => One knob revolution in X or Y results in 26.6mm travel
?hwfactorb y          => Read alternate transmission factor of Y axis only
```

16.14. hwfilter (Handwheel Noise Filter)

```
Syntax:          !hwfilter or ?hwfilter
Parameter:       0 or 1

Description:     This instruction sets or reads the handwheel noise filter
                 state.

                 1 = Noise filter is active (recommended, default)
                 0 = Noise filter is deactivated (finer step resolution)

                 The filter can only be activated/deactivated for all axes.
                 Disabling the filter may result in a finer resolution.
                 But it also may result in some inaccuracy between automatic
                 moves, as its signal noise will cause a permanent slight
                 position jitter.

Response:        Current state of handwheel filter

Examples:
!hwfilter 0      => No noise filter for handwheel, increased finer resolution
?hwfilter        => Read hwfilter state
```

16.15. tbfactor (Trackball Factor)

```
Syntax:          !tbfactor or ?tbfactor
Parameter:       x, y, z, a or none
                 and -200.0 to 200.0

Description:     This instruction sets or reads the trackball sensitivity
                 (transmission factor), which is a floating point number
                 between -200.0 and +200.0. A negative value can be used
                 to change direction (works like 'joydir').
                 The default factor is 1.

Response:        Currently used trackball factor(s)

Examples:
!tbfactor x 100   => X axis is 100 times more sensitive than the default setting
!tbfactor y 12.5  => X axis is 12.5 times more sensitive than the default
!tbfactor 0.5 0.5 => X and Y axis set to half the default sensitivity
?tbfactor         => Read sensitivity factor of all axes
```

16.16. zwheel (Is Z-Wheel Available)

Syntax: ?zwheel or zwheel
Parameter: none

Description: Identify if the connected HDI device provides a Z-Wheel.

0 = HDI device has no Z-Wheel
1 = HDI device has a Z-Wheel

Response: 0 or 1

Example: ?zwheel => 0

16.17. zwtravel (Z-Wheel Travel per wheel revolution)

Syntax: !zwtravel or ?zwtravel
Parameter: 1, 2 or 3 and
-50.0 to 50.0 [mm/revolution]

Description: This instruction sets the travel distances for one revolution of the "Z-Wheel" knob, found on several HDI devices, e.g. ErgoDrive and some Joysticks.
Please check that '**secvel**' and '**vel**' or '**joyvel**' do not prevent from faster traveling when turning the Z-Wheel.

1 = Default (used when no HDI function key is pressed)
2 = Used while Joystick F4 button is pressed (suggested slow)
3 = used while Joystick F1 button is pressed (suggested fast)

Presets for travel distance are
1: 0.1 mm/rev
2: 0.01 mm/rev
3: 1.0 mm/rev

Remarks: If necessary, the default travel may be set to zero (0) for security reasons. So the axis will move only when a key is pressed (F1, F4).

It is also possible to set negative values for direction change. While the '**joydir**' instruction changes the direction in general.

The Z-Wheel can also be assigned to other axes, anyway it is named Z because this is the default axis.
Default, slow and fast is the intended use of the 3 available velocities, but might be assigned as required (slow can be faster than fast etc.)

Response: The travel distance(s) currently assigned to the specified function.

Examples:

?zwtravel	Read all 3 travel distances: [default] [slow] [fast]
?zwtravel 1	Read "default" Z-Wheel travel distance
?zwtravel 2	Read "slow" Z-Wheel travel distance
!zwtravel 3 2.5	Set F1 "fast" Z-Wheel travel to 2.5 [mm/revolution]
!zwtravel 1 0	Set "default" velocity to zero

16.18. zwaxis (Z-Wheel Axis)

```
Syntax:          !zwaxis or ?zwaxis
Parameter:       x, y, z or a

Description:     Assign Z-Wheel to axis (default: z)

Response:        x, y, z or a

Example:         !zwaxis a       (assign z-wheel to axis 4)
                 !zwaxis x       (assign z-wheel to axis 1)
                 ?zwaxis    => z (z-wheel is currently assigned to axis 3)
```

16.19. zwfactor (Z-Wheel Factor)

```
Syntax:          !zwfactor or ?zwfactor
Parameter:       0, 1, 2 ... to 20

Description:     Increase Z-Wheel transmission multiplier, default=1.
                 May be used for Encoder wheels of customer devices
                 which provide less resolution (pulses per revolution).

                   0  = Z-Wheel has no effect
                   1  = Z-Wheel default (1:1)
                 ...
                  20  = Z-Wheel travels 20 times more distance

Response:        Multiplier

Example:         !zwfactor 1       (set default multiplier, as for Nanostep /
Tango HDIs)
                 !zwfactor 5     (set multiplier for lower res. Encoder wheel)
                 ?zwfactor       (Read the currently used multiplier)
```

16.20. tvrjoy (Pulse and Direction Joystick Functionality)

Syntax: !tvrjoy or ?tvrjoy
Parameter: 0, z, a

Description: This instruction enables and assigns the AUX-IO pulse and direction input to an axis for simple joystick functionality. The behavior is similar to the trackball, which is available as HDI device.
Important: This option must not be used for absolute positioning of axes by an external controller. Please use the tvr functionality for this applications.

0 = Disabled (default)
z = Assigned to Z-axis
a = Assigned to A-axis

Response: Currently assigned axis

Examples:
!tvrjoy 0 Disable AUX-IO tvr joystick function
!tvrjoy z Assign AUX-IO tvr joystick function to Z-axis
?tvrjoy Query assigned axis

16.21. tvrjoyf (Pulse and Direction Joystick Factor)

Syntax: !tvrjoyf or ?tvrjoyf
Parameter: -200.0 to +200.0

Description: This instruction sets or reads the tvrjoy transmission factor, which is a floating point number between -200.0 and +200.0. A sign change may be used to change direction. The default setting is 1.

Response: Currently used tvr factor

Examples:
!tvrjoyf 10 Axis is 10 times more sensitive than the default setting
?tvrjoyf Read tvrjoy transmission factor

16.22. hdi (Read HDI ID)

Syntax: ?hdi or hdi
Parameter: none

Description: This instruction reads the ID number of the connected hdi device.
The second value shows how good the hardware ID code matches the theoretical ID value [in %]. This value should be more than 30 for secure device identification.

ID range = 0,1,2, ... 16 (=no device connected)
ID match = 0 (poor) ... 100 (good)

ID	DEVICE
0	Special device (reserved)
1	Coaxial drive (handwheel)
2	Application specific
3	ErgoDrive
4	SmartMove device
10	2x2 Axis Joystick or 4 axis jogbox
11	Trackball + 2 Axis Joystick
12	Joystick 2 Axis
13	Trackball + 3 Axis Joystick
14	Trackball
15	Joystick 3 Axes
16	No device connected
17	(Identification in progress)
18	(Initialization in progress)

Remarks: The instruction may be used to identify the connected HDI device. In addition ‘?zwheel’ can be checked to identify if the device also provides a Z-Wheel.

Response: HDI ID number and the hardware coded ID match in percent.

Example: ?hdi => 12 97 (hdi device nr. 12, 97% match)

16.23. hdimode (HDI Mode Options)

Syntax: ?hdimode or !hdimode
Parameter: Set LSB or more bits at once: string of 0s and 1s,
or single bit with two numbers: 0 to 15 and 0 or 1

Description: This instruction provides access to extended HDI device options.

Options may either be set by a string of bits (0s and 1s) or by specifying bit number and logic state (on/off = 1/0). The string is LSB first (bit 0 is the first and leftmost).

Bit	Function
0:	Toggle Mode for ErgoDrive (0=off, 1=on)
1:	Toggle Mode for Joystick (in KeyMode 1 or 2) 0=select KeySpeed velocitiy XY with F1+F4, Z with F2+F3 1=toggle KeySpeed velocitiy XY by just pressing F1 from firmware 1.56 button F4 toggles Z
2:	- reserved -
3:	- reserved -
4:	- reserved -
5:	- reserved -
6:	- reserved -
7:	- reserved -
8:	- reserved -
9:	- reserved -
10:	- reserved -
11:	- reserved -
12:	- reserved -
13:	- reserved -
14:	- reserved -
15:	- reserved -

Response: Single mode bit or all 16 mode bits as ASCII string

Examples:

!hdimode 100010	Set mode bits 0 and 4 to “on”, bits 1,2,3,5 to “off”. Bits 6...15 are left unchanged.
!hdimode 0 1	Set mode bit 0 to 1 (on) = ErgoDrive Toggle Mode selected
!hdimode 5 1	Set mode bit 5 to 1 (on)
!hdimode 3 0	Set mode bit 5 to 0 (off)
!hdimode 1111	Set mode bits 0,1,2,3 to 1 (on)
?hdimode	Read the current state of all mode bits (returns 16 digits)
?hdimode 0	Read the current state of mode bit 0 (ErgoDrive toggle mode)

16.24. configaxsel (Joystick Axis Select Option)

Syntax: !configaxsel or ?configaxsel
Parameter: 0 or 1

Description: Used in Nanostep / Tango 4 axes systems.
Enable the axis select functionality when the joystick Z-axis should drive both, the controller Z and A axes.
If the A axis joystick is enabled (see remarks), A can be driven instead of Z by pressing F4 key of the joystick.

1 = axis select enabled (pressing F4 key → A-axis used)
0 = axis select disabled (default, joystick z always z axis)

Remarks: Please make sure that the joystick function for A axis is enabled **('joydir a'** instruction)

Response: Axis select configuration

Examples:
!configaxsel 1 Axis select enabled (Z<->A with 3 axes joystick)
!configaxsel 0 Axis select disabled (default)
?configaxsel Read the axis select configuration (returns 0 or 1)

17. Digital and Analogue I/O

The Nanostep / Tango provides several digital I/O, two analogue outputs (channel 0 and 1) and one analogue input. These are available on the optional auxiliary I/O port.
Furthermore the HDI Interface analogue inputs can be read, making some of them optional analog 0-5V inputs if no HDI-device is connected.

17.1. digin (Digital Input)

Syntax:	?digin or digin
Parameter:	none or 0 to 15
Description:	Only available with I/O extension board. This instruction reads the logic state of one or all digital inputs. If no parameter is used all inputs are returned as a string of 16 characters, ASCII 0 or 1, LSB (channel #0) first.
Response:	logic state of digital inputs

Examples:

?digin	read all 16 digital inputs (response e.g. 0000000000000000)
?digin 8	read logic level of digital input 8 (response e.g. 1)

17.2. digout (Digital Output)

Syntax:	!digout oder ?digout
Parameter:	Set LSB or more bits at once: string of 0s and 1s, or single bit with two numbers: 0 to 15 and 0 or 1
Description:	Only available with I/O extension board. This instruction sets or reads back the logic level of the optional digital outputs. Outputs may be set either by a string of levels (0s and 1s) or by channel number and signal level. The string is LSB first (channel 0 is the leftmost).
Response:	current output state

Examples:

!digout 11110000	The digital outputs 0,1,2,3 are set to logic ‚1' and the outputs 4,5,6,7 are set to logic ‚0'. Outputs 8...15 are left unchanged.
!digout 5 1	set digital output 5 to logic 1 (high)
!digout 7 0	set output 7 to 0 (low)
?digout	read the state of all outputs
?digout 8	read the state of output 8

17.3. adigin (AUX-I/O Digital Input)

```
Syntax:          ?adigin or adigin
Parameter:       none or 0 to 3

Description:     Available with the AUX-I/O connector.
                 This instruction returns the logic state of one or all digital
                 inputs on the optional AUX-I/O connector. If no parameter is
                 used all inputs are returned as a string of 4 characters,
                 ASCII 0 or 1, LSB first:

                 0 = Bit 0 = AUX-I/O Pin 1 (Takt In) may not be available!
                 1 = Bit 1 = AUX-I/O Pin 2 (V/R In)
                 2 = Bit 2 = AUX-I/O Pin 3 (Stop)
                 3 = Bit 3 = AUX-I/O Pin 4 (SnapShot2)

Response:        logic state of digital inputs

Examples:
?adigin          read all (4) AUX-I/O digital inputs (response e.g. 1111)
?adigin 3        read AUX-I/O digital input 3 (“SnapShot2”, response e.g. 1)
```

17.4. adigout (AUX-I/O Digital Output)

```
Syntax:          !adigout oder ?adigout
Parameter:       Set LSB or more bits at once:   string of 0s and 1s,
                 or single bit with two numbers: 0 to 3 and 0 or 1

Description:     Available with the AUX-I/O connector.
                 This instruction sets or reads back the logic level of the
                 AUX-I/O digital outputs.
                 Outputs may be set either by a string of levels (0s and 1s)
                 or by individual channel number and signal level:

                 0 = BIT0 = AUX-I/O Pin 5 (TAKT_OUT) may not be available!
                 1 = BIT1 = AUX-I/O Pin 6 (VR_OUT)
                 2 = BIT2 = AUX-I/O Pin 7 (SHUTTER_OUT)
                 3 = BIT3 = AUX-I/O Pin 8 (TRIGGER_OUT)

                 The string is LSB first (channel 0 is the leftmost).

                 Some outputs might not be available here when trigger modes
                 are activated.

Response:        Output state(s), 0 or 1

Examples:
!adigout 1011    Digital outputs 0,2,3 are set to high, output 1 is set to low
!adigout 10      Digital outputs 0 and 1 are set to logic 1(BIT0) and 0(BIT1),
                 outputs 2 and 3 are left unchanged
!adigout 1 0     set digital output 1 to logic 0
!adigout 2 1     set digital output 2 to logic 1
?adigout         read the level of all outputs (e.g. returns 0000)
?adigout 3       read the level of output 3    (e.g. returns 0)
```

17.5. anain (Analogue Input)

Syntax: ?anain
Parameter: c (c = channel)
0 to 15 (channel number)

Description: This instruction reads the current value of one analogue input channel. The range is decimal from 0 (=0V) to 1023 (=5V).

Channel No	Connector	Pin	Signal Name
0	HDI	1	Joystick X
1	HDI	2	Joystick Y
2	HDI	3	Joystick Z
3	HDI	4	
4	HDI	5	Speedpoti
5	HDI	6	
6	HDI	7	
7	HDI	8	
8	HDI	9	
9	HDI	10	HDI-ID
10	**AUX-IO**	**9**	**ANAIN0**
11	internal	-	(PSE)
12	internal	-	V-MOT
13	EXT	20	X-ID0
14	EXT	18	X-ID1 / temp
15	internal	-	REF (2.5V)

Calculating the internal motor voltage:

Umot[V] = (5 / 1023) * [anain c 12] * (55.7/4.7)
More accurate:
Umot[V] = (2.5 / [anain c 15]) * [anain c 12] * (55.7/4.7)

Calculating the internal PSE voltage:

Umot[V] = (5 / 1023) * [anain c 11] * (14.7/4.7)
More accurate:
Umot[V] = (2.5 / [anain c 15]) *[anain c 11] * (14.7/4.7)

Calculating the case temperature (if available):

T[°C] = (250 / [anain c 11]) * [anain c 14]

Example:
?anain c 10 Read value of channel 10 (analogue input of AUX-IO connector)

17.6. anaout (Analogue Output)

Syntax: !anaout or ?anaout
Parameter: 0 to 100 in percent (100% = 10V)
c (c = single channel keyword)
0, 1 or 2 (single channel number)

Description: This instruction sets and reads the analog output signal levels in percent. There are two ways to access, with or without the 'c' keyword (see examples below). This allows to access either a single channel by using the 'c' or channel 0 up to all channels by directly sending the percent values. The signal resolution is typically 14 bit, or 12 bit on older devices (Nanostep / Tango PCI-4).

Fractional numbers may be used, 100% corresponds to 10 Volts.

Channel No.	Connector	Pin	Signal Name
0	AUX-IO	10	ANOUT0
1	AUX-IO	11	ANOUT1
2	reserved	-	-

Response: Analogue output signal level in percent

Examples:
!anaout 100 50.1 Set channel 0 = 100% (10V) and channel 1 = 50.1% (5.01V)
!anaout 75 Set channel 0 = 75% (7.5V)
!anaout c 1 25.3 Set channel 1 to 25.3% (2.53V)
?anaout Read output level of all channels (e.g. 0.00 0.00 0.00)
?anaout c 0 Read output level of channel 0 only (e.g. returns 100.00)

17.7. stoppol (Mode and Polarity of Stop Input Signal)

Syntax: !stoppol or ?stoppol
Parameter: 0 to 5 and 8 to 13

Description: Operating mode of the AUX-I/O “Stop” input.
The modes offer selection of high and low polarities as well as different behaviors like: stop on signal, sticky stop, HDI remaining on or also stopped, immediatly abort running move or complete move first then stop.

0,1 Stop only as long as stop signal is applied
HDI (joystick) remains active!
0 : active low
1 : active high

2,3 Stop only as long as stop signal is applied
HDI (joystick) is also disabled
2 : active low
3 : active high

4,5 Stop signal is latched (sticky), must be released by sending a “!stop 0” instruction
HDI (joystick) is also disabled
4 : active low
5 : active high

6,7 *Not available*

8,9 Same as 0,1 but **a running move will be completed first**

10,11 Same as 2,3 but **a running move will be completed first**

12,13 Same as 4,5 but **a running move will be completed first**

Requirements: In order to be detected, A stop signal must be applied for at least 50µs.
Remarks: Usually the stop input has an internal pull-up resistor to +5V, please refer to the corresponding Nanostep / Tango operating manual.

Response: Operating mode of AUX-I/O stop signal input

Example:
!stoppol 5 Set the function of the AUX-I/O stop input to latched stop active high.

17.8. stop (Release, Force or Check Stop Condition)

Syntax: !stop or ?stop
Parameter: 0, 1

Description: Release or force stop condition in latched '**stoppol**' modes 4, 5, 12 and 13. Or read if stop is active.

0 = Release stop condition (for stoppol 4,5,12,13 only)
1 = Force stop condition (for stoppol 4,5,12,13 only)

Response: -

Example:
!stop 0 release a latched stop
!stop 1 force a stop, in latched stoppol modes only
?stop read if stop is currently active (=1)

17.9. shutter (Shutter Out Signal of AUX-IO)

Syntax: !shutter or ?shutter
Parameter: 0, 1

Description: Set the AUX-IO shutter out signal to the desired TTL level:

0 signal = low
1 signal = high

Response: Output level of shutter signal

Example:
!shutter 1 Set the shutter out signal to TTL high state

17.10. flash (Defined Pulse at AUX-IO Takt Out)

Syntax: !flash or ?flash
Parameter: +-0.00001 ... 32500 [ms]

Description: Sends a pulse of defined length to the AUX-IO TAKT_OUT pin. Used e.g. for LED strobes.

Floatingpoint numbers in [ms].
Range 0.00001 (10ns) to 32500 (32.5s).
Resolution is 1/132µs.

Pulse Polarity depends on sign:
- Positive numbers generate an active high pulse
- negative numbers generate an active low pulse

For safe operation it is recommended to once send one dummy pulse when initializing in order have the correct polarity.

Remarks: **Only available with PCI/PCI-E based controllers and Nanostep / Tango DT.**

Might interfere with secondary trigger output.

Response: None

Example:
!flash 0.001 (high pulse with duration of 1µs)

```
!flash -0.01       (low pulse with duration of 10µs)
```

18. Encoder Instructions

The encoder interface supports incremental encoders with or without a reference mark. The type of encoder (analog 1Vpp, analog MR or RS422/TTL) should be configured by factory, as it might require a different hardware. For Nanostep / Tango Desktop and PCI/PCI-E it is possible to switch from any analog (1Vpp or MR) interface to a digital RS422 interface by setting the encttl parameter to 1.

To enable encoder functionality, first the **encoder mask** has to be set for the corresponding axes. After that, depending on **calmode**, the encoders (enc=1) or also the closed loop will either be activated by calibration of the axis or by power-on.
Manually setting the encoders 'enc' state to 1 is not recommended, as it possibly causes unpredictable in closed loop mode. Also in case of analog MR encoders the signal correction will not be preformed, which leads to positioning errors.

18.1. encmask (Encoder Mask)

Syntax:	!encmask or ?encmask
Parameter:	x, y, z, a or none 0 or 1
Description:	The instruction reads or sets the encoder globally enable mask, which is required to activate the encoders. The encoders then will be detected and activated after a successful calibration instruction '**cal**' or in automatic Closed Loop activation modes (**calmode**) after power up. 0 = clear enable mask (encoder will not be checked/activated) 1 = set enable mask
Response:	Encoder enable mask

Example:

!encmask 1 1 0	Globally enable encoders for X, Y and disable Z-axis
!encmask z 0	Globally disable encoder for Z-axis
?encmask	Read encoder mask state of all axes

18.2. enc (Encoder Active)

Syntax: ?enc (or !enc)
Parameter: x, y, z, a or none
0 or 1

Description: This instruction may be used to query if the encoders are active (e.g. successfully activated by a **'cal'** instruction). It is not recommended to manually activate the encoders by sending any of the "!enc 1" instructions.
For error free Closed Loop behavior and best measuring accuracy, encoders must be activated by the Nanostep / Tango controller.
This depends on **'calmode'**, **'cal'** and **'encmask'**.
For further details please refer to the above mentioned instruction descriptions.

0 = Encoder is inactive (not used)
1 = Encoder is active (used)

Response: Encoder active state

Example:

?enc	Read encoder active state of all axes
?enc y	Read encoder active state of Y-axis
!enc z 0	Disable encoder of Z-axis
!enc 1 1 0	Manually activate encoders of X, Y and disable Z-axis
!enc x 1	Manually activate (not recommended!) the X-axis encoder

18.3. encperiod (Encoder Signal Period)

Syntax: !encperiod or ?encperiod
Parameter: x, y, z, a or none
0.000002 to 4.0 [mm]

Description: This instruction reads or sets the encoder signal period. The unit is always [mm].

Optional read-resolution: As an option to read the parameter with higher precision, the number of required decimal places can be specified with the query "?encperiod [0…16 decimal places]". If no precision is defined, the default resolution is 4 decimal places.

Response: Encoder signal period(s)

Example:

!encperiod 0.5 0.5 0.001	Set encoder period for X and Y to 500µm, Z to 1µm
!encperiod z 0.02	Set encoder period of Z-axis to 20µm
!encperiod 0.00001960784	Set encoder period of X-axis
?encperiod	Read encoder period of all axes
?encperiod z	Read encoder period of Z-axis
?encperiod 12	Read period of all axes with 12 fractional digits
?encperiod z 9	Read period of Z-axis with 9 fractional digits

18.4. encdir (Encoder Counting Direction)

```
Syntax:           !encdir or ?encdir
Parameter:        x, y, z, a or none
                  0 or 1

Description:      Encoder counting direction.
                  Do not set tis parameter when closed loop is active!
                  The encoder direction is set automatically by the Nanostep /
                  Tango controller before activating the closed loop (e.g. after
                  calibration 'cal' or power-on).
                  Only if the axis is not used for closed loop (e.g. only for
                  relative distance measuring) the encdir may be set manually.

                  0 = Encoder counting direction default
                  1 = Encoder counting direction reversed

Response:         Encoder counting direction

Example:
!encdir 1 1 1     Reverse encoder counting direction for all axes
!encdir x 1       Reverse encoder counting direction for X-axis only
?encdir           Read encoder counting direction of all axes
?encdir y         Read encoder counting direction of Y-axis only
```

18.5. encvel (Encoder Auto-Ajust Velocity)

```
Syntax:           !encvel or ?encvel
Parameter:        x, y, z, a or none
                  0.01 ... 20.0 [mm/s]

Description:      The velocity for encoder auto-calibration can be set or read
                  by this instruction. It is recommended to keep the default
                  setting. The unit is always [mm/s].

Response:         Velocity used for Encoder detection and calibration in [mm/s]

Example:
!encvel 0.5 0.5 0.5     Set encoder auto-adjust velocity for all axes
!encvel 0.5             Set encoder auto-adjust velocity for X-axis only
!encvel z 0.5           Set encoder auto-adjust velocity for Z-axis only
?encvel                 Read encoder auto-adjust velocity of all axes
?encvel y               Read encoder auto-adjust velocity of Y-axis only
```

18.6. encttl (Encoder has TTL Signal)

```
Syntax:           !encttl or ?encttl
Parameter:        x, y, z, a or none
                  0 or 1

Description:      This instruction reads or sets the type of encoder signal.
                  If digital encoders (A/B-TTL,RS422) are used with an analog
                  encoder interface (configured for 1Vpp or 5Vpp MR), the
                  corresponding encoder has to be set to TTL mode. Else the TTL
                  signal will be found as invalid (due to signal level) and not
                  be used or deactivated during opration (sporadic malfunction).

                  0 = Encoder has analog sin/cos signals
                  1 = Encoder has digital quadrature A/B signals (e.g. RS422)

Response:         Currently selected encoder signal type(s)

Example:
!encttl 0 0 1     Y and Y axis encoders are analog, Z is digital A/B encoder
!encttl z 1       Set Z encoder signal processing to digital
?encttl           Query all axes for their currently used signal type
?encttl x         Query X-axis for its currently used signal type
```

18.7. encref (Use Encoder Reference Signal)

```
Syntax:           !encref or ?encref
Parameter:        x, y, z, a or none
                  0 or 1

Description:      Use encoder reference mark.
                  If enabled the 'cal' instruction will, after reaching the
                  lower limit switch, travel to the reference mark and set the
                  axis position to zero.

                  0 = Encoder reference signal not used
                  1 = Encoder reference signal used for calibration

Response:         Encoder reference signal used, not used

Example:
!encref 1 1 0     Use encoder reference signal as origin for X and Y-axis
!encref y 1       Use encoder reference signal as origin for Y-axis
?encref           Read Encoder reference signal usage of all axes
?encref z         Read Encoder reference signal usage of Z-axis
```

18.8. encnas (Use Encoder NAS Error Signal)

```
Syntax:           !encnas or ?encnas
Parameter:        x, y, z, a or none
                  0 or 1

Description:      Before enabling this functionality please make sure that the
                  connected encoder provides a NAS error signal.
                  If enabled, a encoder NAS error also generates an internal
                  'err' error state. The NAS input signals an encoder error
                  state by a TTL low level.

                  0 = NAS encoder input state is ignored (default)
                  1 = NAS encoder input signal is used for extended error
                      detection

Response:         Encoder NAS signal used / not used for error detection

Example:
!encnas 1 1 0     Use encoder NAS signal for X and Y-axis
!encnas x 1       Use encoder NAS signal for Y-axis
?encnas           Read encoder NAS signal use state of all axes
?encnas x         Read encoder NAS signal use state of X-axis
```

18.9. encrefstatus (Encoder REF Signal State)

```
Syntax:           ?encrefstatus or encrefstatus
Parameter:        x, y, z, a or none

Description:      Returns the REF signal input state.

                  0 = REF signal is inactive
                  1 = REF signal is active (encoder is on a reference mark)

Response:         Encoder reference signal state

Example:
encrefstatus      Read REF signal state of all axes
encrefstatus x    Read REF signal state of X-axis only
```

18.10. encrefstatusl (Latched Encoder REF Signal State)

```
Syntax:           ?encrefstatusl or encrefstatusl
Parameter:        x, y, z, a or none

Description:      Returns the latched REF signal input state.
                  If the REF signal was active since last reading
                  of the encrefstatusl, a 1 is returned.

                  0 = REF signal is/was inactive
                  1 = REF signal is/was active (encoder is/was on a
                                                reference mark)

Response:         Latched encoder reference signal state

Example:
encrefstatusl     Read+clear latched REF signal state of all axes
encrefstatusl x   Read+clear latched REF signal state of X-axis only
```

18.11. encnasstatus (Encoder NAS Error Signal State)

```
Syntax:           ?encnasstatus or encnasstatus
Parameter:        x, y, z, a or none

Description:      Returns the NAS error signal input state.

                  0 = NAS signal is inactive (encoder signals 'no error')
                  1 = NAS signal is active (error flag is set by encoder)

Response:         Encoder NAS error signal state

Example:
encnasstatus      Read NAS signal (error) state of all axes
encnasstatus x    Read NAS signal (error) state of X-axis only
```

18.12. encerr (Encoder Error State)

```
Syntax:           !encerr or ?encerr
Parameter:        x, y, z, a or none
                  0

Description:      This instruction reads or resets the encoder error state.
                  On error (low signal amplitude 'encamp', or NAS error
                  flag)the encoder signal is invalid and the closed loop for the
                  corresponding axis is switched off.

                  0 = No error, normal function
                  1 = Encoder error

Response:         Encoder error state

Example:
!encerr 0         Reset encoder error
?encerr           Read encoder error states of all axes
?encerr x         Read encoder error states of X-axis only
```

18.13. encamp (Encoder Signal Amplitude)

```
Syntax:           ?encamp
Parameter:        x, y, z, a or none
                  Optional parameter 1

Description:      Read the encoder signal amplitude.
                  100 (percent) represents the maximum undistorted
                  signal amplitude.

Remarks:          In case of single ended TTL encoders the amplitude
                  might be returned as 0.

Response:         Encoder signal amplitude in percent as integer

Example:
?encamp           Read all encoder signal amplitudes (returns e.g. 57 74 0)
?encamp x         Read X encoder signal amplitude
?encamp 1         Read all amplitudes with 1 fractional digit (57.3 73.8 0.5)
?encamp x 1       Read X encoder signal amplitude with 1 fractional digit (57.3)
```

18.14. encpos (Encoder Position)

Syntax:	!encpos or ?encpos
Parameter:	x, y, z, a or none 0 or 1
Description:	Set or read the position source for a **?pos** instruction. If set to 1 and the encoder is active (corresponding **'enc'**=1), ?pos returns the encoder position, else the motor position. Refer to the **'pos'** and **'enc'** instructions for further information.
Remarks:	For compatibility, sending a 0 or 1 without specifying an axis applies the setting to all axes.
Response:	Position output source 0 = pos instruction returns motor position (default) 1 = pos instruction returns encoder position (if enc. active)
Example:	
!encpos 1	from now on a '?pos' instruction returns the encoder position for all axes (if the corresponding encoders are acivated)
~~!encpos 1 1 1~~	Invalid!
!encpos x 1	from now on a 'pos' instruction returns the encoder position for the X -axis (if the encoder is acivated)
?encpos	Use not recommended: Due to compatibility this instruction reads the "ored" position output source of all axes (returns just one 0 or 1)
?encpos x	Read position output source of X-axis

18.15. hwcount (Hardware Counter)

Syntax:	?hwcount or hwcount
Parameter:	x, y, z, a or none
Description:	Hwcount returns the position(s) of the independent TTL encoder counter. It is a digital counter that counts the signal slopes (4 per period) and does not provide signal interpolation. So one signal period corresponds to a counter reading of 4. Also refer to the **'clearhwcount'** instruction.
Response:	Encoder hardware counter value(s)
Example:	
hwcount	Returns the position counter of all axes
hwcount x	Returns the position counter of X-axis only

18.16. clearhwcount (Clear Hardware Counter)

Syntax:	!clearhwcount or clearhwcount
Parameter:	x, y, z, a or none
Description:	Reset the hardware counter(s) to zero.
Response:	Reset encoder hardware counter value(s)
Example:	
clearhwcount	Reset hwcount position of all axes to zero

```
clearhwcount x    Reset hwcount position of X-axis to zero
```

19. MR Encoder Instructions

19.1. mra (MR Amplitude Correction Factor)

```
Syntax:           !mra or ?mra
Parameter:        x, y, z, a or none
                  0.8 to 1.2

Description:      This instruction reads or sets the cosine amplification
                  correction factor of the analogue encoder signal (here:
                  sin/cos amplitude ratio).
                  This factor is calculated automatically on each calibration
                  move 'cal' and should not be changed. If the axis is manually
                  controlled and only used for relative measurement, so that no
                  'cal' is possible, the user may determine the ratio itself and
                  then write it into mra for more accurate results. Please also
                  refer to the 'mro' instruction.

Response:         Currently used correction factor(s)

Example:
?mra              Read MR signal correction factor of all axes
?mra x            Read MR signal correction factor of X-axis only
!mra x 1.0095     Amplify the X cosine signal by *1.0095 compared to the sine
```

19.2. mro (MR Offset Correction Value)

```
Syntax:           !mro or ?mro
Parameter:        x, y, z, a or none
                  -2048 to +2048

Description:      This instruction reads or sets the sine and/or cosine offset
                  compensation value as 16bit signed digits.
                  This factor is calculated automatically on each calibration
                  move 'cal' and should not be changed. If the axis is manually
                  controlled and only used for relative measurement, so that no
                  'cal' is possible, the user may determine the offset itself
                  and then write it into mro for more accurate results. Please
                  also refer to the 'mra' instruction.

Response:         Currently used correction values

Example:
?mro              Read MR signal offset value sine and cosine for all axes
?mro x            Read MR signal offset value sine and cosine for X-axis only
!mro 48 -100 0 0 0 0 0  Set X offset to sin=48digit, cos=-100digit, Y, Z = 0
!mro y 16 -28     Set Y offset to sin=16digit, cos=-28digit
!mro y 16         Set only sine offset of Y encoder
```

19.3. mrp (MR Signal Peak-To-Peak Measuring Result)

```
Syntax:           !mrp or ?mrp
Parameter:        x, y, z, a or none
                  -2048 to +2048

Description:      This instruction reads or sets the sine and/or cosine peak
                  values, measured since they were reset the last time.
                  It is just a measurement and has no effect to the signal
                  processing itself. The returned values are signed 16bit
                  digits.

Response:         [sine max] [sine min] [cosine max] [cosine min] result(s)

Example:
?mrp x            Returns [x_sin max] [x_sin min] [x_cos max] [x_cos min]
?mrp              Returns the above, but for all axes (up to 16 values)
!mrp x 0 0 0 0    Reset the peak-to-peak measurement for x
!mrp x 0 0        Reset only the X sine min, max values
!mrp 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 Reset measurement for all 4 axes
```

19.4. mrt (MR Signal Level)

```
Syntax:           ?mrt
Parameter:        x, y, z, a or none
                  1 to 32767 and -1 to -32767

Description:      This instruction reads the corrected sine and cosine A/D
                  converter results of the analog encoder interface as signed 16
                  bit integer.

                  in case of MR encoders, specifying a negative number returns
                  the corrected analog value (offset, amplitude).

                  The number of data samples (lines) to read should be
                  specified, e.g. '?mrt 1' for returning one sample.
                  If there is no number specified, the instruction returns 10
                  sampling results per default.

Response:         [sine] [cosine] results as signed 16 bit values
                  or [x_s] [x_c] [y_s] [y_c] [z_s] [z_c] for all
                  Each data line is terminated by a [CR].

Example:
?mrt              Returns 10  lines with all axes (up to 6 values per line)
?mrt 1            Returns one line  with all axes (up to 6 values)

?mrt x            Returns 10   lines with [x_sin] [x_cos] signal digits
?mrt x 1          Returns one  line  with [x_sin] [x_cos] signal digits
?mrt y 2          Returns two  lines with [y_sin] [y_cos] signal digits
?mrt y 1000       Returns 1000 lines with [y_sin] [y_cos] signal digits

?mrt -1           Returns one line , all axes with MR correction applied
?mrt x -10        Returns 10  lines, X axis   with MR correction applied
```

20. Closed Loop Instructions

The closed loop control positions the axis to the measuring system position. So the inaccuracy of the drive is compensated. The closed loop control circuit is activated by the "**ctr**" instruction. Also the encoder(s) require the enable request "**encmask**" to be set. To enter the closed loop, either a calibration "**cal**" has to be executed or the power up modes have to be set to **calmode** 1 or 2.

Remarks:
For successfully enabling the closed loop (use the "**ctrstatus**" instructions to check if it is running) it is necessary to have the correct **pitch**, **gear** and **encperiod** settings. The detection tolerance of these parameters is about a factor of 2, else the closed loop will not be activated.

20.1. ctr (Control Enable)

```
Syntax:           !ctr or ?ctr
Parameter:        x, y, z, a or none
                  0,1,2,3,4

Description:      This instruction activates the closed loop circuit.
                  0 = Closed Loop OFF
                  1 = Closed Loop Auto OFF each time position is reached
                  2 = Closed Loop always ON (default, recommended)
                  3 = (currently not supported!)
                  4 = (currently not supported!)

Response:         Closed loop state(s)

Examples:
!ctr 0 0 0 0      Closed loop off for all axes
!ctr 2 2          Closed loop for X- and Y-axis permanently on
!ctr z 1          Closed loop for Z-axis switches off after position reached
?ctr              Read closed loop states of all axes
?ctr x            Read closed loop state of X axis
```

20.2. ctrf (Control Factor)

```
Syntax:           !ctrf or ?ctrf
Parameter:        x, y, z, a or none
                  0.0 to 25.0

Description:      CTRF IS FOR COMPATIBILITY ONLY - PLEASE USE CTRFF.
                  This instruction reads or sets the closed loop factor.
                  Higher values result in more stiffness and faster settlement.
                  Above a critical value this may lead to oscillation.
                  The default factor of 2.0 mostly results in a good behavior.
                  Hint: Using the ctrff instruction instead offers more options.

Remarks:          Even if setting the parameter supports floating point, the
                  return value is integer (for compatibility).
                  It is recommended to use ctrff instead of ctrf.

Response:         Closed loop factors as integers (rounded)

Examples:
!ctrf 2 2 2       Set closed loop factor to 2 for all axes
!ctrf x 3         Set closed loop factor for X axis to 3
?ctrf             Read closed loop factors of all axes (as integer)
?ctrf y           Read closed loop factor of Y axis (as integer)
```

20.3. ctrff (Extended Control Factor)

```
Syntax:           !ctrff or ?ctrff
Parameter:        x, y, z or a
                  0.0 to 25.0
                  0.0 to 25.0

Description:      This instruction reads or sets 2 closed loop factors per axis.
                  Higher values result in more stiffness and faster settlement.
                  Above a critical value this may lead to oscillation.
                  The default factor of 2.0 mostly results in a good behavior.
                  Important: Can only be set per axis (with x,y,z,a parameter)!

                  Parameter1: Is used for regulation while axis is moving
                  Parameter2: Is used for regulation when axis is stopped

                  Parameter 2 can be set to higher values than Parameter1
                  to achieve smoother axis travel while still having the
                  stiffness and faster settling times at the end of a move.
                  (E.g.: "!ctrff x 2 4".)

Response:         Closed loop factors (2 per axis)

Examples:
~~!ctrff 2 2 2 2~~   Not supported!
!ctrff x 2 4      Set closed loop factors for X axis 2(moving) and 4(reached)
?ctrff            Read closed loop factors of all axes (2 parameters per axis)
?ctrff y          Read closed loop factors of Y axis only (2 parameters)
```

20.4. ctrc (Control Call)

Syntax: !ctrc or ?ctrc
Parameter: 1 to 100 [ms]

Description: This instruction reads or sets the controller call interval. Unit is milliseconds. Only one parameter for all axes. The default interval of 5 [ms] in most cases leads to the best results. Values of less than 3 [ms] are not recommended.

Response: Closed loop control call interval in milliseconds.

Examples:
!ctrc 5 Closed loop control is executed every 5 milliseconds
?ctrc Read closed loop call intervall

20.5. ctrd (Control Target Window Delay)

Syntax: !ctrd or ?ctrd
Parameter: 0 to 1000 [ms]

Description: This instruction reads or sets the control delay, which is used as a position reached criteria when in closed loop mode. The closed loop has to remain inside the target window (**twi**) for this time, until the position reached state is set. If the target window is left before the delay time is over, the time starts counting again. Please also refer to the **ctrt** timeout, which aborts the waiting for twi+ctrd after a certain amount of time.

The unit is milliseconds. Only one parameter for all axes.

Response: Closed loop control delay in milliseconds.

Examples:
!ctrd 100 Closed loop controller must be in target window for 100 ms
?ctrd Read closed loop target window delay

20.6. ctrt (Control Timeout)

Syntax: !ctrt or ?ctrt
Parameter: 0 to 10000 [ms]

Description: This instruction reads or sets the control timeout. It specifies the maximum time the closed loop tries to reach the desired encoder position. If the ctrd+twi condition could not be fulfilled within this ctrt time, it will be aborted. If ctrd/ctrt is used, the ctrt timeout must be set to a value which is higher than the ctrd, typically 1 or more seconds. Unit is milliseconds. Only one parameter for all axes.

Response: Closed loop control timeout in milliseconds.

Examples:
!ctrt 1000 Closed loop tries to reach the end position for 1 second
?ctrt Read closed loop timeout

20.7. twi (Target Window)

```
Syntax:           !twi or ?twi
Parameter:        x, y, z, a or none
                  [value corresponding 0.00001 to 1 mm] in dim units

Description:      This instruction reads or sets the closed loop control target
                  window width (+-). While increasing this value leads to
                  position variance, setting a too narrow window may result in
                  oscillation and closed loop timeouts (higher ctrd,ctrt values
                  necessary).
                  The unit depends on 'dim'.

Response:         Closed loop target window.

Examples:
!twi 0.001 0.001  Closed loop target window +-1µm (if dim=2) for X and Y-axis
!twi y 0.005      Closed loop target window +-5µm (if dim=2) for Y-axis
?twi              Read target window of all axes
?twi z            Read target window of Z-axis only
```

20.8. ctrsm (Control behavior outside Lock-in Range)

```
Syntax:           !ctrsm or ?ctrsm
Parameter:        x, y, z or none

Description:      Behavior of the closed loop circuit when outside the lock-in
                  range (ctrs).
                  When outside defined ctrs lock-in range, which is regarded to
                  be an error, the Nanostep / Tango controller can treat this
                  condition as follows:

                  0  = Do nothing (default)
                  1  = Limit the closed loop velocity (avoid stalling the motor)
                  2  = Disable closed loop until returning to lock-in range
                  3  = Disable closed loop permanently
                  4  = Axis is set to sticky stop condition (stoppol 4,5, !stop)
                  5  = Switch off all power stages (like !pa 0)

Response:         Selected Behavior of the axes

Examples:
!ctrsm z 1        Select slow mode in Z (to avoid stalling of the motor)
!ctrsm 5 5 5      Select switch off mode for safety (e.g. collision detection)
?ctrsm            Read all behaviors
?ctrsm y          Read behavior of Y-axis only
```

20.9. ctrs (Control Lock-in Range)

```
Syntax:           !ctrs or ?ctrs
Parameter:        x, y, z or none
                  0.01 to [maxpos]

Description:      Lock-in range of the closed loop circuit.
                  When the closed loop position difference exceeds this limit,
                  the behavior defined with ctrsm is applied to the axis/axes.
                  The unit depends on ‘dim’.

Response:         Closed loop lock-in range.

Examples:
!ctrs 0.5 0.5 0.2 Set lock-in range of X=0.5mm, Y=0.5mm, Z=0.2mm (if dim=2 or 9)
!ctrs z 0.1       Set lock-in range of Z=0.1mm (if dim= 2 or 9)
?ctrs             Read lock-in range of all axes
?ctrs z           Read lock-in range of Z-axis only
```

20.10. ctrstatus (Control Status)

Syntax: ?ctrstatus
Parameter: x, y, z, a or none
optional parameter: 1, 2 or 3

Description: Read the internal closed loop states of the specified or all axes. Options and responses are:

A) Called without parameter:
Returns the internally applied **ctr** state which is set when the closed loop gets enabled by the controller (!cal or calmode=1,2).
0 Closed loop permanently off
1 Closed loop only active while moving
2 Closed loop always on (default closed loop operation)
(3 Closed loop only active while moving)
(4 Closed loop always on)

B) Called with parameter "1":
Check if the closed loop is currently active.
0 = Closed loop not active
(e.g. ctr=0, !cal running, encerr, limit swich, etc.)
1 = Closed loop active

C) Called with parameter "2":
Check if closed loop is in target window.
0 = Position outside target window
1 = Position in target window

A) Called with parameter "3":
Check if closed loop is in lock-in range.
0 = Position outside lock-in range
1 = Position in lock-in range

Response: Closed loop state.

Examples:

?ctrstatus	Returns the internally running ctr mode of all axes
?ctrstatus y	Returns the internally running ctr mode of the Y-axis
?ctrstatus 1	Returns the Closed Loop active state of all axes, e.g. "1 1 0"
?ctrstatus x 1	Returns the Closed Loop active state of the X-axis, e.g. "1"
?ctrstatus 2	Returns if Closed Loop is in target window, e.g. "1 1 0"
?ctrstatus z 2	Returns if Closed Loop of the Z-axis is in target window
?ctrstatus 3	Returns if Closed Loop is in lock-in range, e.g. "1 1 0"
?ctrstatus z 3	Returns if Closed Loop of the Z-axis is in lock-in range

20.11. ctrdiff (Control Position Difference)

Syntax: ?ctrdiff
Parameter: x, y, z, a or none

Description: This instruction returns the momentaryly measured closed loop position difference between the motor and encoder position (mot.pos – enc.pos).
The unit depends on **dim** settings.

Response: Momentary position difference.

Examples:
?ctrdiff Returns the position difference of all axes
?ctrdiff y Returns the position difference of the Y-axis e.g. “0.0015”

21. Trigger Output Functionality (option)

Trigger functionality must be configured by factory.

To find out if the Trigger functionality is accessible, use **'?det'** or 'detext'.

The optional trigger output generates TTL output signals dependend on axis positions or as a constant frequency. It may be used for synchronization of external devices like e.g. a video camera. For Nanostep / Tango Desktop and PCI/PCI-E controllers the trigger output is available with the optional AUX-I/O connector.
Positions or analog values can be captured on a trigger event (SnapShot Mode 8).

Before enabling the trigger function (by '!trig 1'), please make sure that all trigger settings have been made.

```
Example1:   !trig 0[CR]             Disable trigger
            !trigm 0[CR]            Choose trigger mode 0
            !triga x[CR]            Choose X axis as trigger source
            !trigd 0.100[CR]        Set trigger distance to 100µm (if dim = 2)
            !trigs 400[CR]          Set trigger pulse width to 0.4ms
            !trig 1[CR]             Enable trigger and set start position

Example2:   !trig 0[CR]             Disable trigger
            !trigs 120[CR]          Set trigger pulse width to 120µs
            !trigf 2500[CR]         Set pulse frequency to 2.5kHz
            !trigm 100[CR]          Choose trigger mode 100 (periodic signal)
            !trig 1[CR]             Enable trigger
```

Optional "trigcount 0" instruction may be executed to reset the event counter.

21.1. trig (Trigger)

```
Syntax:           !trig or ?trig
Parameter:        0 or 1

Description:      This instruction enables or disables the trigger circuit.
                  "!trig 1" also sets the trigger start position.

                  0 = Trigger function globally disabled
                  1 = Trigger function globally enabled

Response:         0 or 1

Examples:
!trig 1           Enable trigger circuit (also defines the start position)
?trig             Read enable state of trigger circuit
```

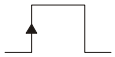
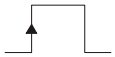
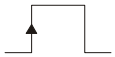
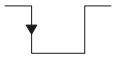
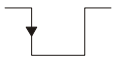
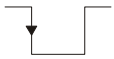
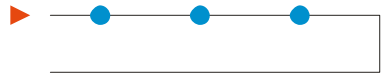
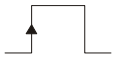
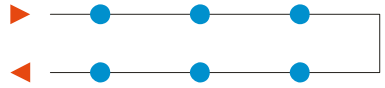
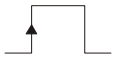
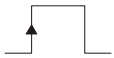
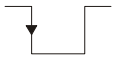
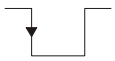
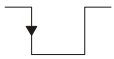
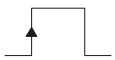
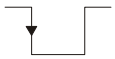
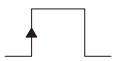
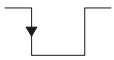
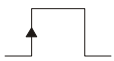
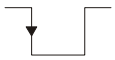
21.2. triga (Trigger Axis)

```
Syntax:           !triga or ?triga
Parameter:        x, y, z or a

Description:      This instruction selects the axis on which to trigger.

Response:         x, y, z or a

Examples:
```

```
!triga y          Select Y-axis as trigger source
?triga            Read current trigger axis
```

21.3. trigm (Trigger Mode)

Syntax: !trigm or ?trigm
Parameter: 0 to 11, 100 to 105
Description: This instruction selects the required trigger mode.

Trigger Mode	Trigger Generation	Trigger Signal	Remarks
0		High active 	First pulse when move starts *Direction forward*
1		High active 	First pulse when move starts *Bidirectional*
2		High active 	First pulse when move starts *Direction backward*
3	-- See Mode 0 --	Low active 	Same as 0, signal inverted
4	-- See Mode 1 --	Low active 	Same as 1, signal inverted
5	-- See Mode 2 --	Low active 	Same as 2, signal inverted
6		High active 	Triggers shifted by trigd/2 *Direction forward*
7		High active 	Triggers shifted by trigd/2 *Bidirectional*
8		High active 	Triggers shifted by trigd/2 *Direction backward*
9	-- See Mode 6 --	Low active 	Same as 6, signal inverted
10	-- See Mode 7 --	Low active 	Same as 7, signal inverted
11	-- See Mode 8 --	Low active 	Same as 8, signal inverted
100	**Periodic trigger** signal the frequency can be set by “trigf” instruction	High active 	Does not depend on position
101		Low active 	
102	**Manually forced** trigger signals by the “trigger” instruction	High active 	Does not depend on position or time
103		Low active 	
104	**Position reached** trigger signal if all moves including the specified axis “triga” have completed	High active 	Comes with the “@@@-.” autostatus response
105		Low active 	

Response: Trigger mode as integer: 0 to 11, 100 to 105

Examples:
```
!trigm 0          Set Trigger Mode 0
?trigm            Read current trigger mode
```

21.4. trigo (Trigger Output)

Syntax: !trigo or ?trigo
Parameter: 0 to 15

Description: This instruction selects the trigger outputs.

With PCI-E based devices the secondary output provides precision options (refer to the trigb Instructions).

Values greater 6 use the secondary (TAKT_OUT) output with the "trigb…" high precision options (precise puls width or pulse delay, precise frequency. Combining precise delay and width is not possible.

Output / Mode	STANDARD	PREC.WIDTH2	PREC.DELAY2	PREC.FREQUENCY2
No output No signal out	**0**	(4)	(8 PCI-E)	(12)
Primary TRIGGER OUT	**1**	(5)	(9 PCI-E)	(13)
Secondary TAKT OUT	**2**	**6**	**10** (PCI-E)	**14**
Both TRIGGER+TAKT	**3**	**7**	**11** (PCI-E)	**15**

Remarks: Options depend on hardware - Nanostep / Tango PCI-E / DT-E based controllers with AUX-IO connector offer all features. PCI-S and DT controllers do not provide the precision Delay function and Tango mini provides none or one output.

Response: Selected trigger outputs

Examples:
```
!trigo 0  No output signal
!trigo 1  Default   trigger output (TRIGGER_OUT)
!trigo 2  Secondary trigger output (AUX-IO TAKT_OUT)
!trigo 3  Both trigger outputs 1:1 (TRIGGER_OUT and TAKT_OUT)
?trigo    Read selected trigger output
```

21.5. trigs (Trigger Signal Length)

Syntax: !trigs or ?trigs
Parameter: 0 to 2621400 [µs]

Description: This instruction is used to adjust the trigger pulse width from 40 microseconds to 2.6214 seconds in increments of 40. (0 = shortest trigger signal width, narrow pulse)
If the parameter is not a multiple of 40 it will be rounded to the next lower multiple (e.g. 100 --> 80). When read back, the corrected value is returned (here: 80).

Response: 0 to 2621400 (µs)

Examples:
!trigs 40 Set Trigger pulse width to 40 µs
!trigs 2500000 Set Trigger pulse width to 2.5 s
?trigs Read current trigger pulse width

21.6. trigd (Trigger Distance)

Syntax: !trigd or ?trigd
Parameter: >0.0 to 5000000 (unit depends on **dim** of the selected axis)

Description: This instruction sets the required trigger distance. After passing this position interval of trigd whith the selected axis, a trigger signal is generated.

Response: Trigger distance

Examples:
!trigd 3.01 Set trigger distance to 3.01mm (if dim of selected axis is 2)
?trigd Read current trigger distance

21.7. trigcomp (Trigger Compensation)

Syntax: !trigcomp or ?trigcomp
Parameter: -10000 ... +10000 [µs] (smallest step is 10µs)

Description: Delay compensation for position trigger (look ahead) to avoid stitching mismatch with bidirectional scan applications.

At high velocity “on the fly” scans, the delay of the trigger signal chain has an effect on where the sample was taken. When scanning in both directions this effect becomes visible (e.g. comb-like appearance of the stitched image). This can be greatly improved or entirely removed by increasing the delay compensation. The delay added by the Nanostep / Tango already is internally compensated, so the default setting is 0.

Remarks: Also check if the scan axis has a mechanical backlash, which can be compensated for open loop applications by using the backlash instruction.

Response: Compensated delay in [µs]

Examples:
!trigcomp 130 Compensate trigger signal chain delay of 130µs
?trigcomp Read the compensation delay (e.g. returns 0)

21.8. trigenc (Trigger on Encoder)

```
Syntax:           !trigenc or ?trigenc
Parameter:        0 or 1

Description:      Trigger position source select, encoder or motor position.

                  0  = Trigger position from motor position (default)
                  1  = Trigger position from encoder (true position)

Remarks:          Encoder position is only used when encoders are active.

Response:         Currently selected trigger position source

Examples:
!trigenc 1        Trigger based on the encoder signal
?trigenc          Read the trigger position source
```

21.9. trigf (Trigger Frequency)

```
Syntax:           !trigf or ?trigf
Parameter:        0.01 to 25000

Description:      This instruction sets the frequency for periodic trigger
                  output mode (trigm 100).
                  The frequency resolution is 1/40µs.

Response:         Trigger frequency

Examples:
!trigf 2500       Periodic trigger pulses have 2.5kHz (signal every 0.4ms)
?trigf            Read trigger frequency
```

21.10. trigbdelay (Precise Trigger Delay for second output)

Syntax: !trigbdelay or ?trigbdelay
Parameter: 0.00 to 32500000 [µs]

Description: Precise delay for secondary trigger output signal (TAKT_OUT).
Applies to trigger output settings !trigo 10 and 11.
Unit in microseconds [µs], resolution is 1/132µs.

Remarks: Secondary trigger can either have precise width or delay.
Only available with Nanostep / Tango PCI-E based controllers.

Response: Delay time in µs

Examples:
!trigbdelay 0.35 Delay the secondary trigger signal by 350ns (to TRIGGER_OUT)
?trigbdelay Read the secondary trigger delay (e.g. returns 0.00)

21.11. trigbwidth (Precise Signal Width for second output)

Syntax: !trigbwidth or ?trigbwidth
Parameter: 0.00 to 32500000 [µs]

Description: Precise width for secondary trigger output signal (TAKT_OUT).
Applies to trigger output settings !trigo 6 and 7.
Unit in microseconds [µs], resolution is 1/132µs.

Remarks: Secondary trigger can either have precise width or delay.
Only available with Tango PCI/PCI-E based controllers.

Response: Signal width in µs

Examples:
!trigbwidth 5.01 Set secondary trigger signal width to 5.01µs
?trigbdelay Read the secondary trigger signal length (e.g. returns 40.00)

21.12. trigbf (Precise Trigger Frequency for second output)

Syntax: !trigbf or ?trigbf
Parameter: 0.010 ... 66000000 [Hz]

Description: Precise frequency for secondary trigger output (TAKT_OUT).
Applies to trigger output settings !trigo 14 and 15.
Unit in microseconds [µs], resolution is 1/132µs.

Remarks: **Only available with Tango PCI/PCI-E based controllers.**
Trigcount does not count the precise trigger events.

Response: Output frequency [Hz] for precise frequency output mode.

Examples:
!trigbf 0.01 Set secondary trigger frequency to 0.01Hz
!trigbf 50000005 Set secondary trigger frequency to 50.000005 MHz
?trigbf Read the secondary trigger frequency (e.g. returns 1000.000)

21.13. trigcount (Trigger Counter)

```
Syntax:           !trigcount or ?trigcount
Parameter:        0 to 2147483647

Description:      This instruction reads or sets the trigger event counter.

Response:         Number of executed triggers

Examples:
?trigcount        Read trigger count
!trigcount 0      Clear trigger counter
!trigcount 110    Set trigger counter to 110 counted events
```

21.14. trigger (Force Trigger Signal)

```
Syntax:           !trigger or trigger
Parameter:        None

Description:      This instruction generates a trigger output pulse. It is
                  available in manual forced trigger modes 102 and 103 only.
                  The pulse width depends on the "trigs" setting.

Response:         None

Examples:         trigger           (Force trigger pulse now)
```

22. Snapshot -Trigger Input Functionality (option)

Snapshot functionality must be configured by factory.

To identify if the Snapshot functionality is configured, use **?det** or detext.

The snapshot functionality allows capturing of X,Y,Z,A axis positions by either pressing a HDI key (e.g. Joystick F2), an external signal or a trigger-out event. Hardware dependent, analog input signals from the AUX I/O connector are captured as well. The values are appended to the snapshot array. The snapshot array can also be filled, extended or manipulated by **snsa**, **!snsp** instructions.

A snapshot event can command the Nanostep / Tango controller to move to positions stored
in the snapshot array (**snsm** 1,5). Every snapshot event moves to the next array entry and wraps around at the end. It can i.e. be used to review memory positions (points of interest) stored in **snsm** 0,4 before.

Snapshot can also start a move (moa, mor, speed) instruction, refer to **snsm** 6.

The snapshot event can be triggered by either
A) the Joystick key F2
B) via the assigned SnapShot input of the optional AUX I/O connector or
C) by a software instruction (**snse**)
Please refer to **snsm** for available snapshot modes.

The position unit depends on the selected dimension **dim**. The setting of **encpos** defines if the motor position or the measured encoder position is read from the array. A maximum of 1024 snapshot positions can be captured.

For changing the snapshot configuration please disable the snapshot (!**sns** 0') and then re-enable it ('!**sns** 1') after all settings have been made.

Remarks:

Most of the snapshot settings can not be stored permanently to the controller.

Requirements:

The Nanostep / Tango controller must be ordered with this function enabled, as it is not available by default or might require additional hardware (e.g. connector).

The snapshot signal must have an active and inactive time of at least 200µs each. Else the signal may not be recognized by the controller.

Example: Three snapshot positions are captured with a 3 axis Nanostep / Tango

Index	Position X	Position Y	Position Z	Position A
1	1.0000	1.2345	1.2345	0
2	2.1200	1.3520	0.9343	0
3	3.5900	1.9000	0.8341	0
4	*invalid*	*invalid*	*invalid*	*invalid*
5	*invalid*	*invalid*	*invalid*	*invalid*
...	...	...	...	...

1024	*invalid*	*invalid*	*invalid*	*invalid*

Here: ?snsc --> 3 ?snsa 2 --> 2.1200 1.3520 0.9343 ?snsa y 1 --> 1.2345

22.1. sns (Snapshot enable/disable)

Syntax: !sns or ?sns
Parameter: 0 or 1

Description: This instruction globally enables or disables the snapshot functionality. Snapshot is globally enabled by default (power-on) in order to support stand-alone applications. Latched key pressed events or the snsm=6 waiting state of a move is cleared when enabling/disabling the Snapshot (sns0,1).

0 = disabled
1 = enabled

Response: Snapshot state

Examples:
!sns 0 Disable snapshot
!sns 1 Enable snapshot
?sns Read snapshot enable state

22.2. snsl (Snapshot Level / Polarity)

Syntax: !snsl or ?snsl
Parameter: 0 or 1

Description: This instruction sets the snapshot input signal polarity.
0 = active low (falling edge)
1 = active high (rising edge)

Response: Currently used snapshot polarity

Examples:
!snsl 0 Set snapshot input to active low
!snsl 1 Set snapshot input to active high
?snsl Read current snapshot input polarity

22.3. snsf (Snapshot Filter)

Syntax: !snsf or ?snsf
Parameter: 0 to 255 [ms]

Description: This instruction reads or sets the snapshot filter time which is used to debounce the snapshot input signals. The value is in milliseconds, 0 to 255.
Debouncing should be used for push-buttons, switches, light barriers etc.
A time of 0 disables the filter, which might be necessary for faster, digitally generated signals. Please note that the minimum high and low times of the input signal must be greater or equal to 200µs each in order to be recognized.

Response: Currently used snapshot filter time

```
Examples:
!snsf 0           Disable input filter
!snsf 10          Set snapshot filter time to 10 ms
?snsf             Read snapshot filter time
```

22.4. snsm (Snapshot Mode)

Syntax: !snsm or ?snsm
Parameter: 0, 1, ... 8

Description: This instruction reads or sets the snapshot mode (default=0).

0 = Capture positions to list with Joystick key F2

1 = Move forward through position list with Joystick key F2 (wraps around at the last element)

2 = Extended move with Joystick keys:
F1: Move backward through position list (wraps around)
F2: Move forward through position list (wraps around)
F3: Move to '**prehome**' then start of list (first element)
F4: Move to '**prehome**' with 'vel' then '**home**' with 'secvel'

3 = Simple continuous path control in conjunction with preloaded **snsa**/**snse** positions (dissection mode).
The path travel velocity is set by scanvel.
Start with Joystick key F2 or corresponding "snse 2".
HDI must be enabled (by joy, joydir) to provide this functionality.

4 = Like mode 0, but Snapshot I/O input is used instead of F2

5 = Like mode 1, but Snapshot I/O input is used instead of F2

6 = Triggered start: Move and Speed instructions will wait for the I/O connector snapshot event to start moving.
Axes must be assigned by the '**snsaxis**' instruction.

7 = Custom HDI mode with Prehome, Home and auto increment in a time interval set by the '**delay**' instruction.

8 = A Trigger-OUT event (not a SnapShot event) captures positions and the ANIN0 analogue signal (of the optional AUX-I/O connector, available with DT and PCI/PCI-E Tangos)

Position capture also captures the analog voltage at the AUX-I/O ANIN0 input pin. For controllers that provide this input the captured voltage can be read by sending '?**snsv**'.

Latched key pressed events or the snsm=6 waiting state of a move is cleared when setting the Snapshot mode.

Remarks: F1-F4 key events can also be generated by '**snse**' 1 to 4.

A snapshot is always executed on all active axes. Capture and move. For snapshot move the position list must be filled with valid positions for all axes.

Response: Currently selected snapshot mode

Examples:

!snsm 0	Set snapshot mode to capture (with joystick key F2)
!snsm 1	Set snapshot mode to move (with joystick key F2)
!snsm 2	Set snapshot mode to extended move
!snsm 8	Set snapshot mode to capture at trigger out events
?snsm	Read current snapshot mode

22.5. Snapshot Mode Description and Examples

Snapshot Mode 1,2,3,7 move functions, accessible via Joystick F1-F4 keys or !snse 1-4 instruction:

Key	Mode 1	2	3 (DISSECTION)	7 ***
F1 =	-	previous point**	-	prehome & home
F2 =	next point	next point**	start dissection	auto inc from 1st point
F3 =	-	prehome & first point	-	pause/continue
F4 =	-	prehome & home	-	pause & previous point

Remarks: A move to the "prehome" positions always travels at secvel.

Prehome & home means that the axes move to prehome and after reaching directly to home. This is used to avoid possible collisions on the way to the home position.
Prehome & first point means that the axes move to prehome and after reaching directly to the first position in the position list. This sequence is also for collision prevention.

**** SnapShot mode 2:**
F3 function must be executed in order to enable the F1 and F2 functionality
F4 disables the F1 and F2 functionality, so pressing F3 is required again

***** SnapShot Mode 7:**
1. Execute a !cal and !rm instruction to define the repeatable, absolute position (origin).
2. Define the !prehome and the !home positions.
3. Define a position list of points using the !snsa instruction.
4. Specify a user delay between the positions by using the !delay instruction.
5. Enter snapshot mode 7 by sending the !snsm 7 instruction.

All information is lost when the Nanostep / Tango controller is switched off or reset.
The delay also applies to all move instructions. So when leaving the snapshot mode 7 it is recommended to reset the delay value back to zero (!delay 0).
Snapshot mode 7 uses the joystick keys F1 to F4 according this specification:

F1 = Go to load/unload position (as defined with the !home and !prehome instructions)
F2 = Start Auto Stage Movement from Point 1 (through position list, defined by the !snsa instruction and using a delay as defined by the !delay instruction)
F3 = Pause/Continue from current position (halt the automatic move)
F4 = Move back one position in the list (when in pause, else it is paused after reaching the next position and then it moves back.)

instruction sequence example for snsm 7:

```
!cal
!rm
!sns 0
!delay 1000                                  (delay between moves e.g. 1000ms)
!prehome [Xpos] [Ypos] [Zpos] [Apos]         (specify load position)
!home [Xpos] [Ypos] [Zpos] [Apos]            (specify unload position)
!snsa 0                                      (clear the snapshot array / position list)
!snsa 1 [Xpos] [Ypos] [Zpos] [Apos]          (load position list)
!snsa 2 ...                                  (load position list) ...
... !snsa N ...                               ...
!snsm 7                                      (enter snapshot mode 7 for F1-F4 functionality)
!sns 1                                       (activate snapshot function globally)
```

(From Nanostep / Tango firmware 1.57 autoincrement can be aborted by the abort "a" instruction)

SnapShot Mode 3 (dissection, simple continuous path functionality):
Typical applications are laser dissection or adhesive dosers/dispensers.
Remarks: All axes must be idle and all axis positions must be loaded with valid entries.
The simple continuous path functionality has a continuous increase in position deviation that will build up during the sequence (about 10µm). Interpreter is blocked.

```
!scanvel [mm/s]                              (set the path/vector velocity)
!sns 0
!snsa 0                                      (clear the snapshot array / position list)
!snsa 1 [Xpos] [Ypos] [Zpos] [Apos]          (load position list)
!snsa 2 ...                                  (load position list) ...
... !snsa N ...                               ...
!snsm 3                                      (enter snapshot dissection mode 3)
!sns 1                                       (activate snapshot function globally)
!snse 2                                      (start the dissection sequence, or press F2 key)
?err                                         (send a request and wait for reply --> completed)
```

22.6. snsc (Snapshot Counter)

Syntax:	!snsc or ?snsc
Parameter:	none, 0 or 1 to 1024 (not greater than the current snsc count)
Description:	This instruction reads or sets the snapshot counter, which shows the snapshot array entries (counted snapshot events). This instruction may also be used to reset the counter to zero or reduce the size of an existing array.
Response:	Current snapshot array entries (number of snapshot events)

Example:

?snsc	Read the number array entries (e.g. captured snapshots)
!snsc	Clear snapshot counter to zero elements
!snsc 0	Clear snapshot counter (same as without parameter)
!snsc 50	Reduce snapshot array entries to 50 (only if the current snsc value is equal or higher than the new value)

22.7. snsi (Snapshot Index)

Syntax:	!snsi or ?snsi
Parameter:	0 to 1023 (less than the current snsc count)
Description:	This instruction reads or sets the snapshot array pointer. In snapshot modes 1 and 5 this pointer access can be used to manipulate the array index where move target positions are read from. Opposed to other snapshot instructions the index range here is [0...N-1] instead of [1...N]. The value must be less than the amount of **snsc** array entries.
Remarks:	The pointer is only used for the snapshot move. It does not define the array index where positions are written to. Captured positions are always appended as the last element of the array. For array manipulations by software please refer to **'snsa'** and **'snsp'**.
Response:	Current snapshot array pointer

Example:

?snsi	Read the current array pointer position
!snsi 0	Set array pointer to the first element
!snsi 20	Set array pointer to the 21st element

22.8. snsaxis (Snapshot Axis)

Syntax: !snsaxis or ?snsaxis
Parameter: x, y, z, a or none
0 or 1

Description: Defines which axes should wait in Snapshot mode 6.
Please refer to '**snsm**' for further information.
When sending a moa, mor or speed instruction with snsm 6, axes can be specified that should not execute the move until triggered by a snapshot-in event. This can be used in cases where precise start timing has to be controlled by an external signal (maybe also set the '**trigf**' value to zero then).

1 = move or speed of this axis will wait for snapshot signal
0 = axis does not wait for snapshot signal (default operation)

Remarks: If not all axes are set to waiting mode, a vector move may start some of the axes wihle the others are waiting.
Such problem does not exist when using single axis move/speed instructions.

Response: Wait mode setting of the axes

Example:

!snsaxis 1 0 1	Set axis X, Z to waiting mode, Y does not have to wait
!snsaxis y 1	Set axis Y to waiting mode
?snsaxis	Read waiting mode of all available axes (e.g. returns "0 0 0")
?snsaxis z	Read waiting mode of Z axis only (e.g. returns "1")

22.9. snsp (Snapshot Position)

Syntax: !snsp or ?snsp
Parameter: x, y, z, a or none
Positions (unit depends on "**dim**")

Description: This instruction reads the most recently captured Snapshot Position. It can also be used to append new positions to the Snapshot position array. The snapshot counter '**snsc**' will be incremented automatically. Please also refer to '**snsa**'.

Remarks: The unit of the position data depends on selected '**dim**' value.

Only motor positions can be read. In order to read captured encoder positions, please refer to '**?snsa**'.

Response: Last captured Snapshot position of the specified axis or of all available axes

Examples:

?snsp	Read last captured snapshot position of all axes
?snsp z	Read last captured snapshot position of Z axis only
!snsp 10 20 30	Append new motor position entry for X, Y and Z axis
!snsp y 2000	Append new position entry with Y-axis only (not recommended)

22.10. snsa (Snapshot Array)

Syntax: !snsa or ?snsa
Parameter: x, y, z, a or none
-1, 0 or 1 to 1024

Description: Read, fill, modifiy or clear the snapshot position array, which may contain up to 1024 elements.
For reading a valid element, the index must have a value between 1 and the maximum of the snapshot counter value.
Please also refer to '?**snsc**'.
To append new position data to the array, an index of [snsc+1] or index=-1 may be used. The Snapshot counter then will be incremented by 1 automatically.
Parameter: -1 = last/append, 0 = clear, 1...1024 = r/w access.

Remarks: The unit of the position data depends on selected '**dim**' value.

The read position values are either motor positions or encoder positions, depending on active encoders and '**encpos**' settings.
Encoder position is only available with captured positions, not when the position entry was written by software (!snsp or !snsa). In this case the encoder position is read as 0 and '**encpos**' should be set to 0 for reading this position.

Response: Snapshot array position(s) in '**dim**' units.

Examples:

?snsa 1	Read all axis positions of the first snapshot entry
?snsa 33	Read all axis positions of the 33rd snapshot entry
?snsa z 99	Read the Z-axis position of the 99th snapshot entry

```
?snsa y -1          Read the Y-axis position of the last snapshot entry
?snsa -1            Read all axis positions of the last snapshot entry
!snsa 0             Clear the entire snapshot array
!snsa x 1 20.5      Set X position of first element to 20.5 (e.g. mm if dim=2)
!snsa 2 10 10 10 10 Set all axis positions of the second array entry to 10
!snsa -1 10 10 10 10 Append a new entry to the position array (snsc is incremented)
```

22.11. snse (Snapshot Event)

```
Syntax:             !snse or snse
Parameter:          1, 2, 3 or 4

Description:        Executes the F-key Snapshot functions via the communication
                    interface. Instead of pressing a Joystick button or using the
                    AUX-I/O signal, the functions can be triggered by software:

                    1 = Function normally executed by pressing Joystick F1 key
                    2 = Function normally executed by pressing Joystick F2 key
                        or using the AUX-I/O SnapShot input
                    3 = Function normally executed by pressing Joystick F3 key
                    4 = Function normally executed by pressing Joystick F4 key

Remark:             Behavior is the same as with the function keys. It depends
                    on the snapshot mode settings and only works when Snapshot
                    is enabled. Does not work with Snapshot Mode 8, as this mode
                    requires trigger out signals being generated by the Nanostep /
                    Tango.

Response:           -

Example:
snse 2              Execute F2 Snapshot event (e.g. capture current position to
                    the snapshot position array)
```

22.12. snsv (Snapshot Voltage)

```
Syntax:             !snsv or ?snsv
Parameter:          1 to 1024 or -1 to -1024

Description:        Read the AUX-I/O ANIN0 input voltage (0...5V), captured at the
                    specified position array index. The value can also be written
                    to (i.e. as temporary data storage)
                    Index > 0: read Voltage in [mV]
                    Index < 0: read raw ADC data

Remarks:            The specified index must be in the range of 1 to +-'snsc'.
                    The [mV] values are always calculated with the internal
                    voltage reference, while the raw data is the direct ADC
                    sampling result which may be less accurate (only PCI-E
                    based Nanostep / Tangos have an accurate ADC sampling result).
                    The raw data range is always 12bit, but with PCI-S based
                    controllers the 2 LSBs are always zero (10bit resolution).

Response:           Voltage in [mV] or in [12bit ADC raw data]

Example:
?snsv 2             Read captured Voltage [mV] of 2nd snapshot array entry
?snsv -2            Read captured Voltage [raw] of 2nd snapshot array entry
!snsv 5 1234        Store the value 1234 in 5th snapshot array voltage element
```

22.13. prehome (Snapshot PreHome Position)

Syntax: !prehome or ?prehome
Parameter: x, y, z, a or none

Description: This instruction sets the prehome position used by the snapshot extended move. The unit of the input position depends on the setting of **"dim"**.
Please refer to **"snsm"** 2 for more details.

Response: Position value(s)

Examples:

!prehome y 10.2	Set prehome position Y-value to 10.2 (e.g. [mm] when dim=2)
!prehome 10 0 20	Set prehome position X,Y,Z
?prehome x	Read currently used prehome position of X axis only
?prehome	Read currently used prehome positions of all axes

22.14. home (Snapshot Home Position)

Syntax: !home or ?home
Parameter: x, y, z, a or none

Description: This instruction sets the home position used by the snapshot extended move. The unit of the input position depends on the setting of **"dim"**.
Please refer to **"snsm"** 2 for more details.

Response: Position value(s)

Examples:

!home y 10.2	Set home position Y-value to 10.2 (e.g. [mm] when dim=2)
!home 10 0 20	Set home position X,Y,Z
?home x	Read currently used home position of X axis only
?home	Read currently used home positions of all axes

23. Document Revision History

No.	Revision	Date	Changes	Remarks
01	A	27. March 2012	Newly revised and extended document version	Based on Nanostep / Tango firmware revision 1.57
02	B	12. April 2012	Added instructions: Ecomove, noled, calrequired, joychangeaxis, ctrsm, ctrs, trigo, trigcomp, trigenc, snsi, snsaxis, snsv, zwfactor, detext, posclr, maxaxis, trigbwidth, trigbdelay, trigbf, encrefvel, vrm, flash, etspresent, stagesn Added stop and stoppol modes	Based on Nanostep / Tango firmware revision 1.57