

Instruction manual ***Linear Controller 3 Axes*** **LC3**

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



CE

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1 Introduction

This manual describes the 3 axis digital linear stage controller LC3 from **piezosystem jena**.

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

If there are any problems, please contact the manufacturer of the system: **piezosystem jena**, Stockholmer Str. 12, 07747 Jena, Germany. Phone: +49 36 41 66 88-0.

2 Certification of **piezosystem jena**

The company **piezosystem jena GmbH** has worked according to a DIN EN ISO 9001 certified quality management system since 1999. Its effectiveness is verified and proven by periodic audits by the TÜV.



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

3 Declaration of conformity

The CE Declaration of Conformity is available on our website **www.piezosystem.com**.

4 Purchased part package

- Please check the completeness of the delivery after receiving the shipment:
- Linear Controller **LC3**
- power cord
- USB cable
- instruction manual

For optional needed drivers or available software see our homepage.

5 Instructions for using piezo electrical elements and power supplies

- Linear stages from **piezosystem jena** are controlled by voltages up to 250V. These values can be quite hazardous. Therefore, read the installation instructions carefully and ensure that only authorized personnel handle the power supply.
- After transport, all units should be allowed to adapt to room temperature for approximately two hours before being switched on. No condensation of humidity on the units is allowed.
- Do not connect or disconnect cables between the LC3 controller and linear stage while the controller is switched on. After turning off the power switch, wait five seconds before connecting or disconnecting a cable.
- In the event of damages of cable, cable insulation, connectors or other units, switch off the device and contact **piezosystem jena** for repair service.
- Please use only original parts from **piezosystem jena**.

Please contact **piezosystem jena** or your local representative if there are any problems with your actuator or power supply.

Caution! Shock forces may damage the unit. Please avoid such forces, and handle the units with care, otherwise the guarantee will be lost.

6 Safety instructions

Icons:



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



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

RISK OF ELECTRIC SHOCK!

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

CAUTION!

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

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

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

6.1 Installation, power supply

RISK OF ELECTRIC SHOCK



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

CAUTION!



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

6.2 Operation

RISK OF ELECTRIC SHOCK!



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

CAUTION!



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

6.3 Maintenance and inspection

CAUTION! 

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

6.4 Environmental conditions

The controller can be used:

- indoors only
- at an altitude of up to 2000 m
- at a temperature between: 5 ... 35 °C
- at a relative humidity between: 5 ... 95 % (non-condensing)
- in clean environments without electrically conductive dust

The recommended environmental conditions:

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

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

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

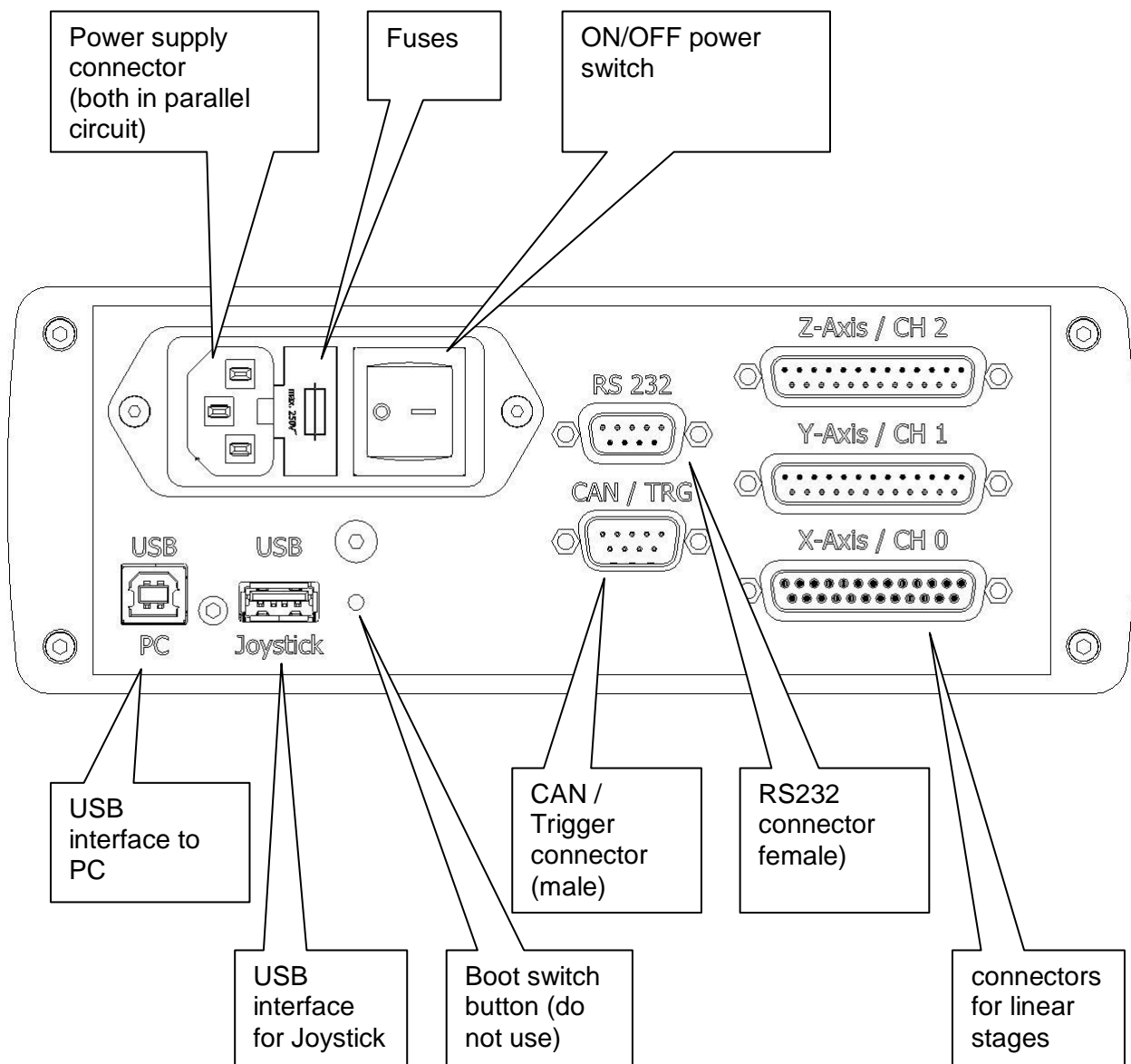
- If the packaging material is damaged, please confirm this with the shipping company.
- Connect the linear stage actuator by using the D-SUB 25pin connector. Be sure the cables are connected properly to the electronics.
- Connect the controller to PC with an USB cable.
- Connect the power supply.
- Normally, the PC installs necessary drivers automatically.
- In case of irregularities, please read the chapter on *troubleshooting*.
- The function check is complete.

8 How to operate the linear stage controller

8.1 Common introduction

The controller **LC3** has been designed to control linear stages from **piezosystem jena**. It allows controlling different linear stages. All information needed is stored on the ID-chip, located in the stage, and will be read by the controller after the boot. The three axis can work independently.

8.2 Connectors (back side)

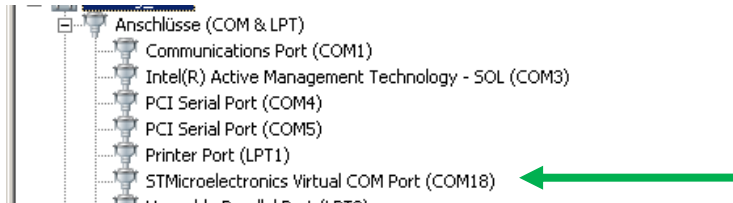


8.3 Interfaces

8.3.1 USB interface to PC

This interface is normally used to control by a host PC. A standard USB A/B cable can be used.

8.3.1.1 Driver Installation



After connecting and powering the LC3, the Windows Device Manager should show a device named "STMicroelectronics Virtual COM Port", the Port number (here COM18) is to be used for communication.

8.3.2 USB interface to Joystick

This interface can be used with the Joystick, provided by piezosystem jena. Other USB devices will not work.

8.3.3 RS232 interface (optionally)

This interface is similar to USB-PC interface. It is used to control the device by RS232.

The RS232 interface uses following parameters:

Baud rate	115200
Handshake	no handshake
Data bits	8
Parity	none
Stop bits	1

Pinning:

Pin	Signal
2	TxD
3	RxD
5	GND, Ground

8.3.4 CAN interface (optionally)

Pinning of D-Sub connector (male):

Pin	Signal
2	CAN_L
3	GND, Ground
7	CAN_H

8.3.5 Trigger interface (optionally)

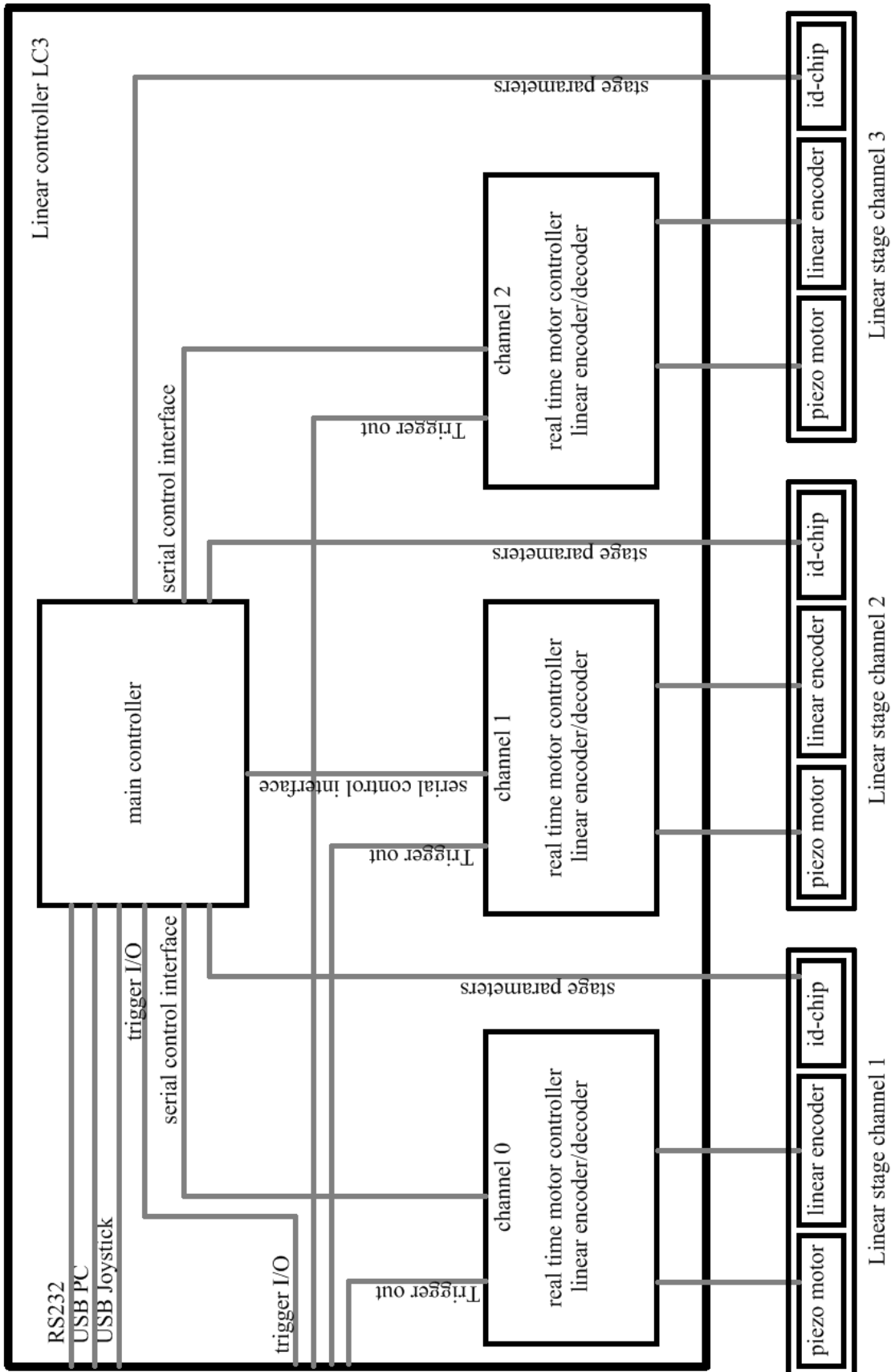
The trigger interface can be used to trigger external devices by using the trigger outputs. Alternatively, the LC3 controller can be triggered by external devices (not implemented yet). All inputs are pulled up to 3.3 V by resistor 10 k, the inputs are 5 V tolerant. All outputs use 5 V TTL level, with an impedance of 47 Ω .

Pinning of D-Sub connector (male):

Pin	Function	Remarks	Polarity	Type
1	Trigger out A μ C	Trigger A from main controller	high active	output, 5 V TTL, 47 Ω
2	Trigger out B μ C (option 1: combined trigger X, Y, A) (option 2: Trigger out Stage Z)	Trigger B from main controller or combined (ored) trigger from pins 1,5,9	high active	output, 5V TTL, 47 Ω
3	/Interlock input	with option interlock, the pin must be pulled low to enable the stage motor	low active	input, pull up 10 k Ω
4	Trigger input B	not implemented		input, pull up 10 k Ω
5	Trigger out Stage X	Trigger output from stage real time controller, stage X / channel 0	high active	output, 5 V TTL, 47 Ω
6	Ground	also connected to case / mains earth		
7	Ground	also connected to case / mains earth		
8	Ground	also connected to case / mains earth		
9	Trigger out Stage Y	Trigger output from stage real time controller, stage Y / channel 1	high active	output, 5 V TTL, 47 Ω

8.4 Function

The following sketch shows the function groups of amplifier:



sketch 1: function groups of the controller

8.5 Real time motor controller

The motor controller and the piezo motors are third party components from the Nanomotion Ltd. Following explanations were taken from "User Manual XCD Firmware ver 1.6" Doc. Nr. XCD0458004-00 Rev. A.

XCD CONTROLLER FLOW

The XCD controllers are based on a standard PIV (position/velocity loop) controller with a non-linear mechanism. The controller uses several mechanisms to control movement of the stage:

- Offset mechanism
- Zero feed-forward mechanism
- Dead zone mechanism

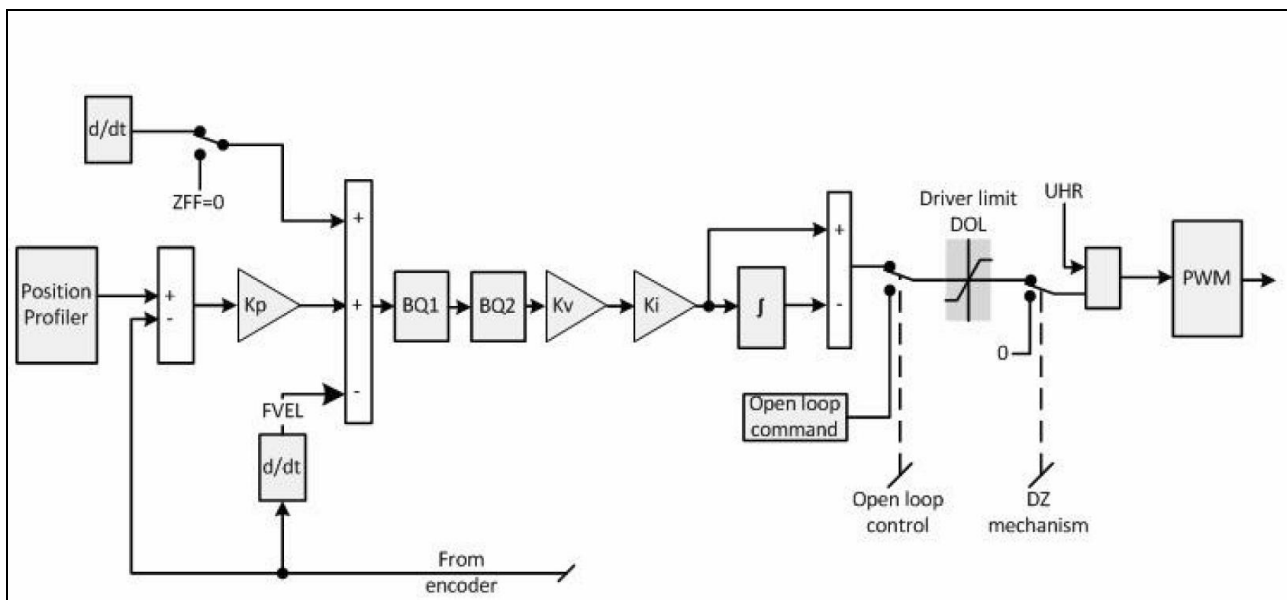


Figure: Controller Block Diagram

POSITION PROFILER

When the controller receives a MOVE command it calculates a position signal profile that defines the expected stage positions at 50 μ sec intervals. The profile includes three phases:

- Acceleration (ACC)
- Constant velocity (VEL)
- Deceleration (ACC)
- Position (RPOS)

The ACC parameter is a $\langle \text{userUnit} \rangle / \text{sec}^2$ value used for both acceleration and deceleration. Note that for a linear stage the value is mm/sec^2 and for a rotary stage it is $\text{degree}/\text{sec}^2$. During acceleration (ACC) the controller supplies a signal that increases motor speed. After the motor reaches the configured velocity (VEL) the controller maintains the velocity by changing the drive command. As the stage approaches the target position the controller begins to reduce the drive command.

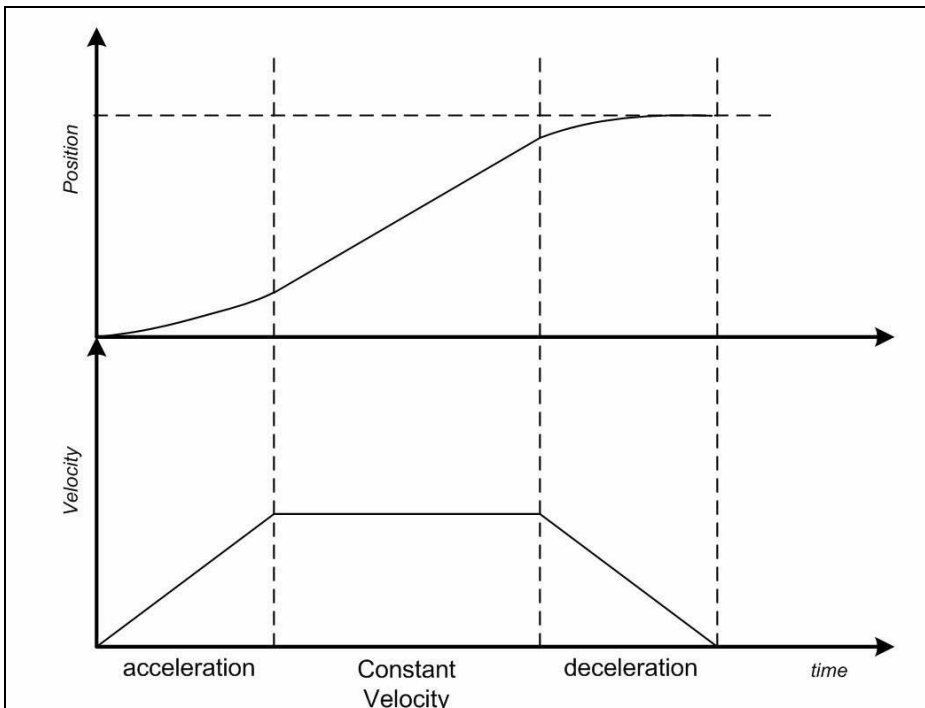


Figure: Position and velocity profile change over time

CONTROL ALGORITHM

Kp (Proportional Gain)

The proportional gain (K_p) determines the contribution of restoring force that is directly proportional to the position error. If K_p is set to zero, only the velocity loop is used in the algorithm. This restoring force acts similar to a spring in a mechanical system. Each sample period (servo tick) the PID loop calculates the position error as the difference between the instantaneous trajectory position and the primary feedback position and multiplies the position error by K_p to produce the proportional component of the 16-bit DAC command output. An axis with a too small value of K_p is unable to hold the axis in position and is very soft. Increasing K_p , stiffens the axis and improves its disturbance torque rejection. However, a too large value of K_p often results in instability.

Kv (Velocity Feedback)

Determines the contribution of restoring force (damping) proportional to the velocity of the motor/actuator, and is therefore the most important control gain. If K_v is set to zero, no control is applied to the profile. If K_v is set too high the system will produce an ultrasonic sound. The velocity feedback derivative is calculated and updated every Servo tick. Velocity feedback is estimated through a combination of speed-dependent algorithms. At high speeds, velocity is simply the change in position per sample. This method is used for smoother performance when estimating velocities less than one encoder count per sample derivative sample period.

Ki (Integral Gain)

The integral gain (K_i) is applied after K_v and determines the contribution of restoring force that increases with time, ensuring that the static position error in the servo loop is forced to zero. This restoring force works against constant torque loads to help achieve zero position error when the axis is stopped. Each sample period (Servo Tick), the position error is added to the accumulation of previous position errors to form an integration sum. This integration sum is scaled by dividing by 256 prior to being multiplied by K_i . In applications with small static torque loads, this value can be left at its default value of zero. For systems with high static torque loads, this value should be tuned to minimize position error when the axis is stopped.

LI (Integrator Limit)

The integrator limit is expressed in percent and limits the contribution of the integrator gain to the motion profile. A valid input is in the range [0,100].

ENCODER FEEDBACK

The encoder provides feedback of the stage (rotary or linear) position. After mounting on the stage, the parameter ENR (Encoder Resolution) provides a conversion of the encoder resolution to user units (mm, degrees, radians etc). For additional information about the ENR parameter refer to ENR on page 24 on XCD Software Manual.

ZERO FEED FORWARD (ZFF) MECHANISM

The zero feed forward mechanism improves the motors settling time. This is done by stopping the velocity feed forward (VFF), reducing the speed at which the motor approaches the target position. As shown in the block diagram, VFF provides a value derived from the position profile. The ZFF parameter is set as a value of between 30 and 50 microns from the target position. The value of ZFF is dependent on the moving mass. For a larger mass ZFF should be increased.

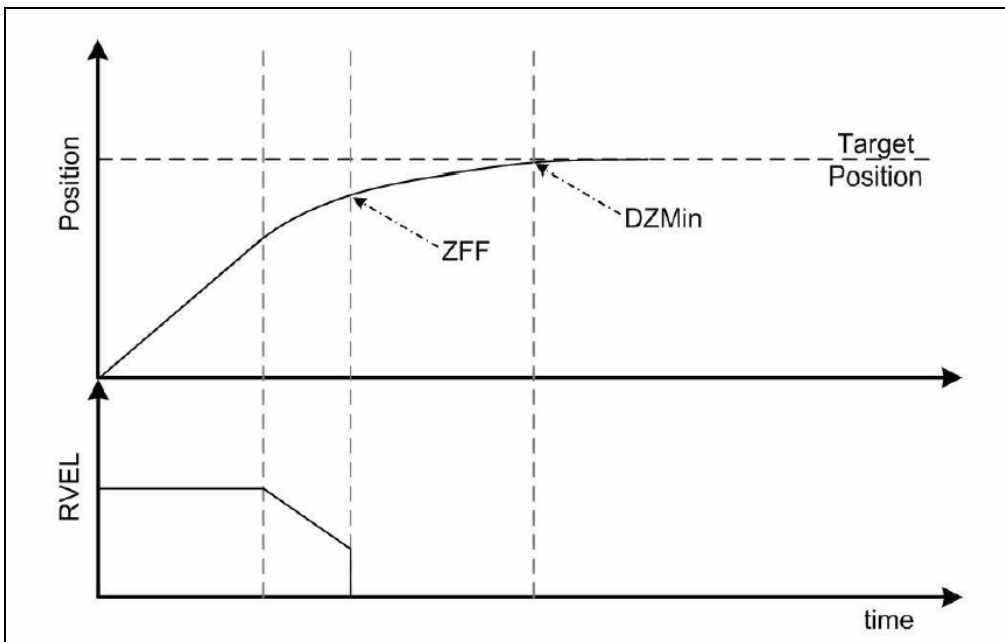


Figure: Approach to Target Position

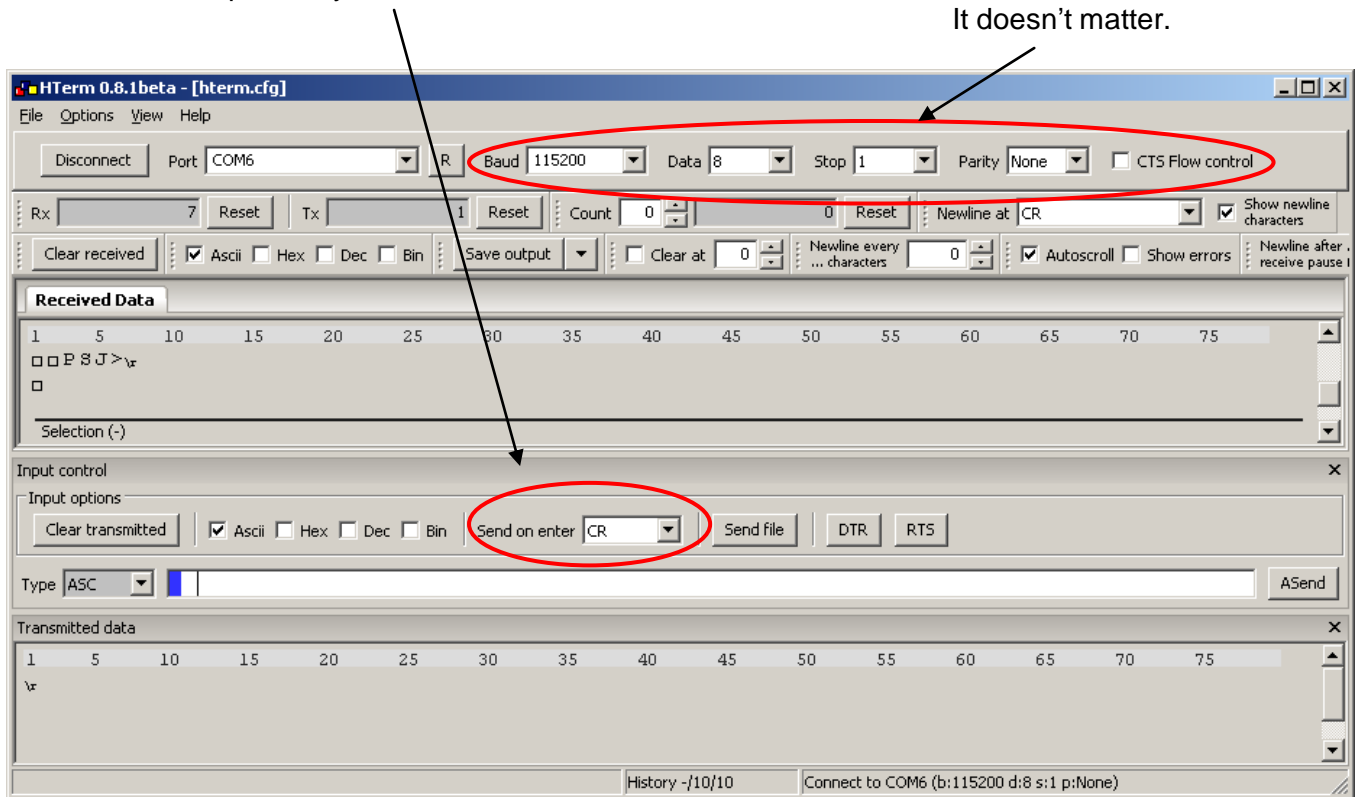
8.6 Technical data

	LC3
Input voltage:	100-240 V (limits 85-264 VAC, 47-440 Hz)
Power supply connector:	IEC-60320 C13/C14
Input current:	typ. <500 mA, max. 1A
Fuse	1 A slow blow
channels	3
Actuator connector	25pin D-Sub socket
Display	TFT, 320x240 pixel
Interface	USB, optionally: RS232, CAN, Trigger I/O
PC Interface connector	USB type B
Joystick interface connector	USB type A
Cooling	passive
Dimensions (l w h):	240x210x80mm ³
Weight:	2.2 kg

Table: technical data

8.7 Communication

The **LC3** can easily communicate with your PC with the use of a terminal program such as HTerm. A USB connection cable is required to connect to your computer. It is not necessary to set up any properties of the COM port, because it is set by the virtual COM port driver. Be sure that any command is completed by <CR> character.



When the device is powered and connected, it answers after receiving “CR - carriage return” (enter key) with its prompt “LC3>”.

8.8 Handling

Stage connecting: Connect stage or axes always in ascending order, starting with “channel 0 / x-axis”.

	channel 0 / x-axis	channel 1 / y-axis	channel 2 / z-axis
one axis in system	•		
two axes in system	•	•	
three axes in system	•	•	•

In general: all commands must end with character “Carriage Return” (0x0d or \r).

Initialization:

After startup, the position encoder counter starts with 0.0 mm, but the real stage position is unknown. Therefore the position encoder must be initialized by detecting a reference mark. This can be done by command “pinit”. Alternatively, an automatic initialization can be enabled by command “pinit_en,0/1” after startup. After the initialization procedure, the stage is ready for normal work.

Stage moving:

The stage can be moved by command “move,channel,position”, with target position in mm. The total travel range (see stage datasheet) is split into equal parts around the initial position (e.g. if the total travel range is 120 mm, the stage can move from -60.000 mm to +60.000 mm). For two-axis applications, the command “m2” allows the simultaneous movement of two axis by using “m2,xposition,yposition”

Predetermined positions:

With the commands “pos1” and “pos2”, two positions (per axis) can be predefined. The positions are stored in EEPROM and still available after restart. By using the commands “mpos1” and “mpos2”, the stage moves to the predetermined position.

Home position:

The home position can be defined by “home,channel,value” and will be stored in EEPROM. The single command “home” (without a parameter) sets the actual position as home position. The home position (all axes simultaneously) can be reached by “mhome”.

Incremental moving:

With the parameters “del1, channel” and “del2,channel”, two incremental movements (delta) can be realized. The movement is started by “mdel1,channel” and “mdel2,channel”. The commands can be repeated until the maximum stage travel range is reached. If the command is used without a channel parameter, all active channels will move.

Range limitation (soft limit):

The travel range of each axis can be limited by setting software limits in positive and negative moving directions. Use the commands “slp,channel,positive limit” or “sln,channel,negative limit”.

8.9 Command list

Commands without parameter (request)

Command	Description
s	request list of all commands (read only)
mhome	move to home position (channel optional)
mdel1	move delta 1 (channel optional)
mdel2	move delta 2 (channel optional)
mpos1	move to predefined position 1 (channel optional)
mpos2	move to predefined position 2 (channel optional)
pinit	initializes encoders, move to zero position
status	device status request (read only, decimal output format)
status2	device status2 request (read only, decimal output format)
rgver	firmware version controller (read only)
serno	controller serial number request (read only)
version	request firmware version of motor driver board (read only)
t	prints trigger result list (optionally)

Commands with parameter and without channel: <command>,<value> Enter (CR = "\r"= 0x0D_h= 13_d)

Command	Description	Parameter / Value
pinit_en	Position center drive on startup en-/disable	0 = off, 1 = on
m2	move both axes, gives trigger on output A when position reached	x,y x=X-position in mm y=Y-position in mm
phase	swap X and Y on joystick	0 = normal, 1 = swapped
joyen	joystick enable / disable	0 = off, 1 = on (always on after booting)
curve	line trajectory movement with optional trigger output	without or with one parameter: without = print curve list 0 = clear curve list 1 = start scanning curve list 2 = abort scanning
curve	add curve / scan line	with four parameters: x,y,triggermode,trigger increment x = X endpoint y = Y endpoint triggermode: 0= no trigger 1= X-axis 2=Y-axis trigger increment = trg distance in mm
savezone	trigger free area in mm, used with command curve	trigger free area in mm

Commands with channel and without value: <command>,<ch> Enter

Command	Description	Channel
fpos	request stage Position	0,1,2
kill	stops "move"-command	0,1,2
status	status of device motor drivers	0,1,2
status	status of device	without parameter

status2	status2 of device	without parameter
prog	programm status motor driver board	0,1,2
version	version of motor driver board	0,1,2
fac_reset	factory reset	0,1,2

Command with value: <cmd>,<channel>,<value> Enter

Request the value: <cmd>,<channel> Enter

Main control unit commands:

Cmd	Description	Channel	Value range
move	moves to position	0 = X 1 = Y 2 = Z	stage depending, in mm
home	set home position	0,1,2 or no parameter	no parameter or mm
del1	set delta 1 increment	0,1,2	stage depending, in mm
del2	set delta 2 increment	0,1,2	stage depending, in mm
pos1	set position 1	0,1,2	stage depending, in mm
pos2	set position 2	0,1,2	stage depending, in mm
inv	invert joystick move direction	0 = X 1 = Y 2 = Z	0 = normal 1 = inverted
ppi	trigger impuls at waypoint	0,1,2	channel,start,increment,count

Real time controller commands:

Command	Description	Channel	Value range	Default
vel	velocity in mm/s	0,1,2	0 to 250	25
acc	acceleration in mm/s ²	0,1,2	0 to 250	100
ppw	trigger impuls width in ms	0,1,2	0.001 to 0.26	0.1

Real time loop controller commands (do not change without our consent)

kp	Position Loop Gain	0,1,2	0 to 200	100
kv	Velocity Loop Gain	0,1,2	0 to 2	1
ki	Position Loop Integrator	0,1,2	/	300
li	Velocity Loop Integrator	0,1,2	/	50
enr	Encoder Resolution in mm	0,1,2	/	0.00004
dzmin	Dead zone min in mm	0,1,2	min 0.00008	0.00008
dzmax	Dead zone max in mm	0,1,2	min 0.0004	0.0004
zff	Zero feed forward in mm	0,1,2	0.02 to 0.04	0.03
frp	Friction in positive Direction	0,1,2	0 to 100	10
frn	Friction in negative Direction	0,1,2	0 to 100	10
dol	Drive Output Limit	0,1,2	100	100
slp	soft limit positive	0,1,2	0 to +½ travel range	0=disabled
sln	soft limit negative	0,1,2	0 to -½ travel range	0=disabled
pel	Positon error limit	0,1,2	/	1
tel	Time error limit	0,1,2	/	0.0
mtl	Motion time limit in ms	0,1,2	/	stage dependent

8.10 Trigger outputs (optional)

With optional trigger outputs, external devices can be controlled according to actual stage positions.

There are three different modes to generate trigger outputs.

The **first mode** involves setting the trigger generation first and then move the stage by the move command. Before using the trigger, set the length of trigger pulses with command "ppw,channel,trigger length". The trigger length is stored for each axis and applies until it is set again. Configure the trigger output by the command "ppi,channel,start,increment,count", with:

Channel: moved channel with trigger generation (0,1,2)
 Start: start position of trigger output (1st trigger point)
 Increment: trigger increment, distance between trigger points (in mm)
 Count: number of trigger points

Be sure that you overrun the complete trigger range, otherwise the trigger generation will not work correctly.

After each trigger scan, the trigger must be reconfigured by the ppi command.

The trigger function can also disabled by command "ppi,channel,0,0,0" with cannel=0/1/2.

Example for trigger mode 1:

```
ppw,0,0.1           sets the length of trigger pulses to 0.1 ms

move,0,-21          //move x to -21 mm (start position x)
move,1,-5           //move y to -5 mm (start position y)
ppi,0,-20,2,10     //set trigger pulses: 1st pulse at -20 mm, trigger every 2 mm, 10 trigger
                   points
move,0,1            //move x to +1 mm (y stay at -5 mm)

                   // trigger points at: -20,-18,-16, ... , -2 mm
```

The **second trigger mode** can scan a 2-D array with trigger generation and uses the following commands and parameters:

Define area without trigger:

savezone,value = area without trigger (value in mm)

Trajectory control:

curve = list curve points (edges)
 curve,0 = clear curve list
 curve,1 = run curve list
 curve,2 = abort curve list running

Define trajectory points:

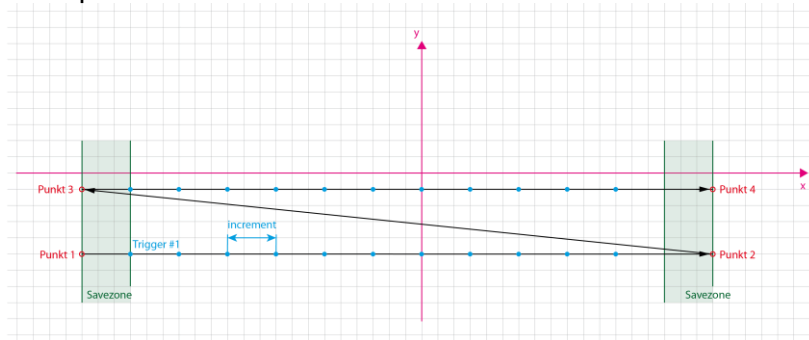
Curve,posX,posY,trigger,increment = add a curve point to list

Result output:

t = output trigger list

The first trigger is always (pointX + savezone) or (pointY + savezone).

Example:



```

vel,0,10.0 //velocity x-axis 10 mm/s
vel,1,1.0 //velocity y-axis 1mm/s
ppw,0,0.1 //impuls width on x-axis 100 µs
savezone,3.0 //trigger after 3mm
curve,0 //clear curve table
curve,-21.0,-5,0,0.0 //point 1: without trigger to start
curve,18.0,-5,1,3.0 //point 2: trigger x every 3 mm (note: last trigger is in savezone)
curve,-21.0,-1,0,0 //point 3: start next line without trigger
curve,18.0,-1,0,1,3.0 //point 4: trigger next line every 3 mm
curve,1 //run curve
t //output trigger points
  
```

The **third trigger mode** is use the command `m2,x,y`, hereby a trigger will be generated after both axes reached their set positions.

8.11 Device status words

There are three kinds of states:

- Device status of main controller axis controller (cmd "status")
- Extended status of axis controller (cmd "status,channel")
- Extended status of device (cmd: "status2")

Command: "status"

Byte 3	Byte 2	Byte 1	Byte 0
Board Z	Board Y	Board X	Controller

Controller (Byte 0)							
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
moving	d2	d1	set	CAN	RS232	Joystick	COM

- bit 0: USB communication
- bit 1: joystick connect/enable
- bit 2: RS232 enable
- bit 3: CAN enable
- bit 4: Joystick "Set mode" enable
- bit 5: Joystick "D1" step mode
- bit 6: Joystick "D2" step mode
- bit 7: one or more axis are moving

Board (Byte 1-3)							
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
moving	inverse	biquad2	biquad1	mode	eprom	motor	board

bit 0: board communication possible
 bit 1: motor/stage connected
 bit 2: eeprom read-/writeable
 bit 3: driver mode
 bit 4: Biquad filter1 enable
 bit 5: Biquad filter2 enable
 bit 6: moving inverse
 bit 7: axis is moving

Extended status of axis controller
Command: "status,<channel>"

bit 0: script run
 bit 1: s_queue
 bit 2: s_move
 bit 3: s_busy
 bit 4-7: reserve
 bit 8: open loop
 bit 9: velocity_loop
 bit 10: position_loop
 bit 11: reserve
 bit 12: biquad-filter1
 bit 13: biquad-filter2
 bit 14: non-stop-mode
 bit 15: reserve
 bit 16: low resolution
 bit 17: motor connected
 bit 18: inverse feedback
 bit 19: inverse drive
 bit 20: simulation mode
 bit 21-23: reserve
 bit 24: logical motion
 bit 25: hold position
 bit 26: kill flag
 bit 27-31: reserve

Extended status of device
Command: "status2"

Byte 0							
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
						interlock flag (stored)	interlock status (live)

bit 0: 0= OK, 1= locked (this bit represents the live status of interlock pin)
 bit 1: 0= OK, 1= interlock event stored (this bit is automatically cleared after read out)

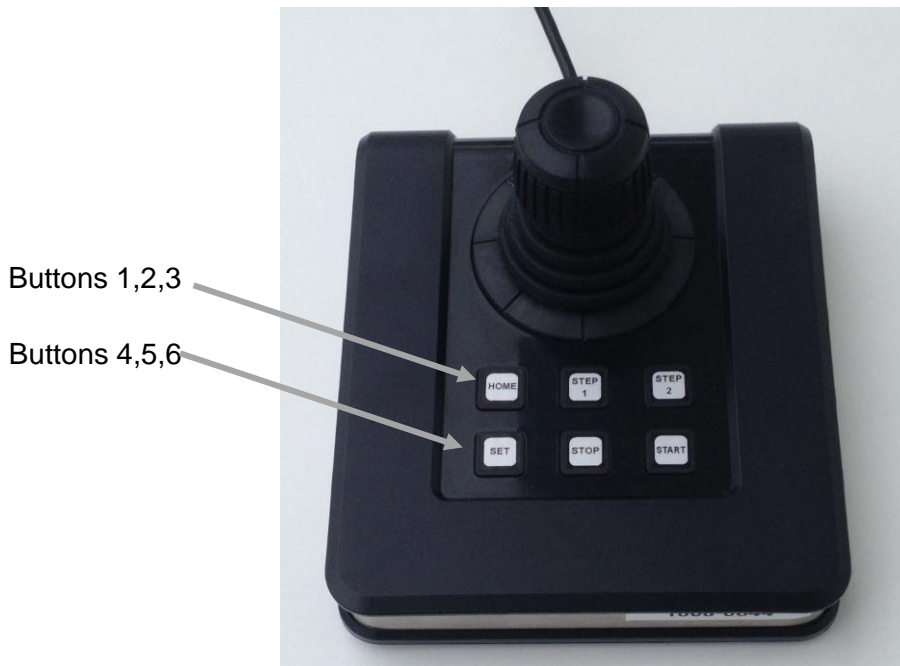
8.12 Joystick functions

The joystick can be enabled with the command "joyen,1" or disabled with "joyen,0". After the system booting, the joystick is always enabled.

It is possible to change the button functions. The default joystick has six buttons. The command counter starts from zero.

Button	Function No.	Description
	0	Disable / none function
1	1	Home function: set or move to home
2	2	D1 function: set delta1 or enable delta1 step mode*
3	3	D2 function: set delta2 or enable delta2 step mode*
4	4	Set function: Activate/deactivate set-mode*
5	5	P1 funktion: set or move to position 1
6	6	P2 funktion: set or move to position 2

*see on display, if enabled



The joystick allows a free movement of the stage with a velocity depending on the displacement angle of the stick.

The buttons have the following functions:

Home button: the stage moves to predefined and stored home-position (see also commands: "home" and "mhome").

D1 button: activates / deactivates the incremental moving mode by delta1 parameter (commands "del1" and "mdel1"), a tip on joystick moves the dedicated way in the assigned direction

D2 button: similar to D1 button

P1 button: The stage moves to predefined position1 (commands: "pos1" and "mpos1")

P2 button: The stage moves to predefined position2 (commands: "pos2" and "mpos2")

Set button: activates the settling mode for buttons "Home", "D1", "D2", "P1" and "P2"

Activate settling mode and press "Home" button: sets actual position to home position.

Activate settling mode and press "P1" button: sets actual position to predefined position1, the same for button "P2".

Programming Delta1 and Delta2:

1. move to home position
2. move the desired way in one or two dimensions
3. press "Set" button
4. press "D1" or "D2" button

The differences between home position and set position are the new increments "delta1" or "delta2".

Note1: Any predefined position or interval can be easier programmed by USB command.

Note 2: If the joystick axes or moving directions don't meet the physical stage movement or the microscope image, the axis can be changed by the commands "phase" (swappes X and Y) "inv" (changes moving direction).

With the command "joyfunc,<button>,<function>", the button functions can be changed.

Examples:

joyfunc,0,1

Set "home"-function to button 1

joyfunc,3,0

disable button 4

8.13 Error codes

Code	Error
0	No Error
1	Unknown command
2	Missing parameter
3	Wrong parameter
4	Timeout error
5	Hardware error