MAN02 – SOFTWARE USER MANUAL

CRYO & NANO PRODUCTS

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RELEVANT DOCUMENTATION

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[1]	CNP-Products_MAN00_R01_Getting-Started.pdf (JPE)
[2]	C181055_APN01_Rxx_CPSC_Modes_Of_Operation.pdf (JPE)
[3]	C181055_APN02_Rxx_Using-Linux-OS.pdf (JPE)
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DEFINITIONS

ABBREVIATIONS

DLL	Dynamic Link Library
CLI	Command Line Interface
GUI	Graphical User Interface

1. INTRODUCTION

Thank you for using JPE's Cryo & Nano Products!

This manual describes the control and operation via software of *Cryo & Nano Positioning Systems* (from here on described as *systems*) using JPE's cryogenic compatible actuators (from here on described as *actuator*). These actuators can be operated by using a (modular) Controller System (from here on described as *controller*).

Please read this document carefully prior to installation and (initial) operation of the controller, (stand-alone) actuators and systems. Failure to observe the safety regulations results in a risk of mortal electric shock and/or damage to the controller(s), actuator(s) and/or system(s)!

JPE shall not be liable for damage or injury resulting from misuse of the controller system(s), actuator(s) and/or device(s) or unauthorized alterations to either of those.

All products mentioned in this manual are intended for use in a laboratory and/or scientific research environment only and may only be installed, maintained and used by higher educated, technical skilled personnel (from here on described as *operators*).

1.1 Document version

This *User Manual* assumes using the latest products and controller software: **v7.3.yyyymmdd.**

Please note that all content in this document is superseded by any new versions of this document. Visit the JPE website (www.jpe-innovations.com) to obtain the most recent version[1]. All images in this document are for illustrative purposes only.

1.2 Prerequisites

Before continuing with this user manual, please make sure to read and understand the contents of the (latest version of the) Cryo & Nano Products Getting Started Guide (MAN00) as well as the applicable Product User Manuals.

[1] This *User Manual* is intended for products ordered and/or delivered from **January 2021 onwards**. If you are using older products you might require to consult a different User Guide / User Manual, which can be found on the JPE website (click on the button "Download User Software & Manuals").

2. CONTROLLER DRIVER SETUP

2.1 System requirements

To be able to control actuators and systems via software, a PC system with (at least) Windows 7 (SP1) (32bit or 64bit) and one free USB port (at least USB2.0) is required. For optimal performance it is best not use a hub device. Alternatively, the controller can be connected to a Local Area Network (LAN) using a standard CAT5e/CAT6 (or comparable) cable.

2.2 Download User Software

Download a copy of the latest *User Software* from the JPE website. Go to Cryo & Nano Products > Cryo Positioning Systems Controller (CPSC) > click on the button *"Download User Software & Manuals"*. Select the applicable .zip file and unpack the content of the .zip file to a folder of your choice.

The software is portable, meaning there is no further installation (or setup) required.

Currently the user software is only natively available for Windows OS. Integration in third-party (control) software (like Matlab® or LabView®) is supported by the Command Line Interface (see chapter 4). Running the software in Linux is possible when using the Windows-emulator "Wine"[2].

2.3 Connection through USB

1 Log on to Windows with an account with (full) *Administrator* privileges.

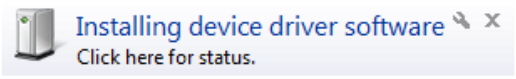
2 Place the controller on an appropriate surface (for example a sturdy workbench) and make sure that no actuators or systems are connected to the controller.

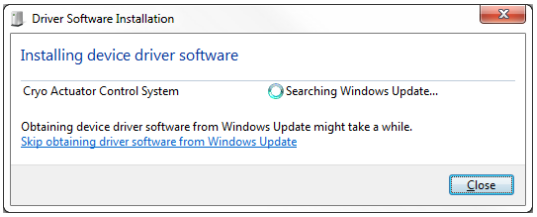
3 Make sure that the *Mains Power Switch* on the back of the controller is in the "0" (OFF) position.

4 Connect the supplied USB cable to the back of the cabinet (connector labelled "USB") and on the other end to a free USB port.

5 Power on the cabinet, switch the Mains Power Switch to the "1" (ON) position.

6 Windows will automatically detect new hardware. Because the controller uses a standard Human Interface Device (HID), a suitable driver should be found. Most likely this will result in (one or more of) the following message(s):





[2] Visit www.jpe-innovations.com > Cryo & Nano Products > Cryo Positioning Systems Controller (CPSC)

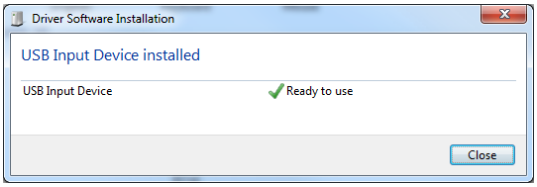


Figure 1: Installing software messages

(Please note that the screenshots above may vary depending on the version of operating system that is being used)

7 After successful installation, the *Device Properties* should look (similar) to this:

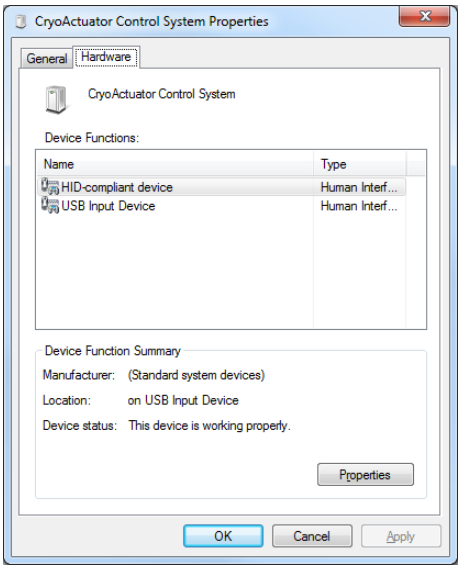


Figure 2: Driver properties

(Go to Start > Devices and Printers > *(right-click) on* (Unspecified) Cryo Actuator Control System > *select* Properties > *tab* Hardware*)*

8 Driver installation finished.

2.4 Connection through LAN

Alternatively, the controller can be connected to a *Local Area Network* (LAN) using a standard CAT5e or comparable cable. By default, the DHCP function is enabled, so that after connecting to a LAN, the controller can get an IP address automatically[3].

1 Place the controller on an appropriate surface (for example a sturdy workbench) and make sure that no actuators or systems are connected to the controller.

2 Make sure that the *Mains Power Switch* on the back of the controller is in the "0" (OFF) position.

3 Connect a CAT5e/CAT6 (or comparable) cable to the back of the cabinet (connector labelled "LAN") and on the other end in to a free LAN port.

[3] This requires a DHCP Server to be active on the Local Area Network.

4 Power on the cabinet, switch the Mains Power Switch to the "1" (ON) position.

Should the controller not be able to get an IP address via DHCP, it is possible to manual enter an IP address using the Command Line Interface (CLI) or Graphical User Interface (GUI). In that case it is required to connect the controller to a PC via USB first, to be able to set the IP address in the controller. Read Chapter 5.4 for further instructions.

Note that it is only possible to use one connection type at a time, so either USB or LAN. If the controller is connected to both, USB has the highest priority (and will be selected over LAN).

3. SOFTWARE STRUCTURE

3.1 Components

The User Software consists of three main components:

- A (Windows OS) *Dynamic Link Library*, from here on described as ***DLL*** (`JpeCpscLlDll.dll`), which contains all the functions required to communicate with the controller and to be able to generate the correct drive profiles for the actuators and systems, as well as performing various safety checks.

- A *Command Line Interface*, from here on described as ***CLI*** (`cacli.exe`), which is a non-graphical program that can run from the (Windows) command prompt and uses the DLL to communicate with the Controller. The CLI can also be easily integrated in 3rd party control software like for example LabView® or MATLAB®.

- A *Graphical User Interface*, from here on described as ***GUI*** (`cagui.exe`). The GUI provides an easy-to-use visual tool to operate actuators and systems and uses the DLL to communicate with the Controller as well. Besides the standard operate functions, the GUI will also provide basic diagnostics, calibration functionality and sensor data readout.

> ***Important note****: A GUI for v7.x user software is in development, but not yet ready for release.*

3.2 Modes of operation

The controller can be used in different *operation modes*:

- *Basedrive*. Set-and-forget type of positioning. Can be used open-loop or closed-loop using the Optical Encoder Module (OEM2) or Resistive Sensor Module (RSM). Can be used in the CLI and GUI.

- *Servodrive*. Uses internal position feedback control to address multiple (position) setpoints per controller (closed-loop). Servodrive requires the Optical Encoder Module (OEM2) or Resistive Sensor Module (RSM) installed and is only available as function of the CLI.

> *Note that Servodrive supports up to 3 actuators in closed-loop per controller cabinet! If more axes are to be used in Servodrive mode, additional cabinets are required.*

- *Flexdrive*. Most dynamic operation mode, but requires a customer supplied Data Acquisition System. Requires the use of the CLI to set the CADM2 module into *External Input Mode*.

For more information, please read the Application Note *"CPSC – Modes Of Operation"* (APN01) [REF02].

4. COMMAND LINE INTERFACE (CLI)

Before continuing, make sure to follow the proper setup and installation as described in the Getting Started Guide.

Note that the controller can be used in different Modes of Operation, see paragraph 3.2. With the CLI it is possible to use the controller in Servodrive or Flexdrive mode of operation. Specific commands or parameters combinations for the CLI will define the mode of operation the controller is in.

The CLI enables easy integration with 3rd party control software (for example LabView® or MATLAB®) to be able to program movement sequences, to enable Servodrive or to set the CADM2 module in *analog input mode* (Flexdrive) for example.

Note that the CLI cannot run at the same time as the GUI (or vice versa); only one can have control over the controller (the controller is always slave to the GUI or CLI).

Upon power on of the cabinet please wait a few seconds for the controller to boot, before using the CLI.

The CLI is a single file `(cacli.exe)` that is called from the (Windows) command prompt and needs various arguments to work:

```
cacli COMMAND [parameters] {enter}
```

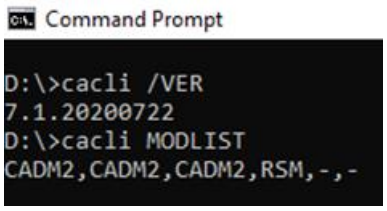


Figure 3: CLI example

4.1 Addressing a controller

4.1.1 USB

If only one controller is connected through USB, there is no need to define the target device (as it is selected by default).

If more than one controller is connected to the same PC via USB, the user has to define the target device for communication. Targets are defined by the *controller ID#* (printed on a sticker on the back of the controller). The first argument preceded with `@`, will define the target device. This argument needs to precede any other command arguments. For example:

```
cacli @1038E201807-05 COMMAND [parameters] {enter}
```

4.1.2 LAN

If one (or more) controller(s) is (are) connected via LAN, the user has to define the target device for communication. Targets are defined by their *IP Address* (see paragraph 2.4). The first argument preceded with `@`, will define the target device. This argument needs to precede any other command arguments. For example:

```
cacli @192.168.15.80 COMMAND [parameters] {enter}
```

4.2 Command overview

A quick summary of all available commands (COMMAND) for all available modules and *modes of operation*.

Command	Description	Module	Mode of operation	Paragraph
MODLIST	Get information about installed modules	n/a	n/a	4.4.1
IPR	Read IP settings from controller			4.4.2
IPS	Configure IP settings for controller			4.4.3
/STAGES	List of supported actuator and stage types			4.4.4
/LAN	Scan for LAN connected controllers			4.4.5
/USB	Scan for USB connected controllers			4.4.6
/VER	Get CLI version information			4.4.7
FIV	Get Firmware version information			4.4.8
FU	Firmware Update	{All}		4.4.9
DESC	Get information on installed module	CADM2	n/a	4.5.1
GFS	Request fail-safe state		n/a	4.5.2
MOV	Move		Basedrive	4.5.3
STP	Stop			4.5.4
SDC	Scanner Mode			4.5.5
EXT	Use External Input		Flexdrive	4.5.6
PGV	Get current position	RSM	Basedrive	4.6.1
PGVA	Get current position of all 3 channels			4.6.2
MIS	Set negative end stop			4.6.3
MAS	Set positive end stop			4.6.4
MIR	Read negative end stop			4.6.5
MAR	Read positive end stop			4.6.6
MMR	Reset negative and positive end stop			4.6.7
EXS	Set excitation duty cycle			4.6.8
EXR	Read excitation duty cycle			4.6.9
RSS	Save settings in non-volatile memory			4.6.10
CGV	Get current counter value	OEM2	Basedrive	4.7.1
CSZ	Reset current counter value to zero			4.7.2
DGV	Get current encoder signal value			4.7.3
OEMC	Automatic Optical Encoder Module calibration			4.7.4
MLS	Request calibration values			4.7.5
DSG	Set detector gain			4.7.6
DSH	Set upper threshold value			4.7.7
DSL	Set lower threshold value			4.7.8
MSS	Store calibration values to nonvolatile memory			4.7.9
EGC	Request current state of all Interrupter Channels	EDM	Basedrive	4.8.1
EGCL	Request latched state of all Interrupter Channels			4.8.2
EGV	Request current signal strength of a single Interrupter Channel			4.8.3
EGVA	Request current signal strength of all Interrupter Channels			4.8.4
EGE	Request current state of all External Digital Inputs			4.8.5
EGVE	Request current signal value of all External Analog Inputs			4.8.6
MLC	Request gain and threshold values of a single Interrupter Channel			4.8.7

MLG	Request power setting and active state of all Interrupter Channels			4.8.8
EIN	Set active state of all Interrupter Channels			4.8.9
SID	Set signal power of all Interrupter Channels			4.8.10
SIG	Set gain of a single Interrupter Channel			4.8.11
SHT	Set upper threshold of a single Interrupter Channel			4.8.12
SLT	Set lower threshold of a single Interrupter Channel			4.8.11
LDI	Turns signal power of all Interrupter Channels OFF			4.8.14
LMI	Turns signal power of all Interrupter Channel to MIN			4.8.15
LMA	Turns signal power of all Interrupter Channels to MAX			4.8.16
MSF	Store all settings to nonvolatile memory			4.8.17
FBEN	Enable Servodrive	{All}	Servodrive	4.9.2
FBXT	Disable Servodrive			4.9.3
FBCS	Go To setpoint			4.9.4
FBES	Emergency Stop			4.9.5
FBST	Get status position control			4.9.6

4.3 Common drive parameter arguments

The command line interface accepts `[parameters]` in a particular order. Depending on the first command `[COMMAND]` one of multiple other parameters are required. Common drive and/or sensor parameters are:

Parameter	Value	Description
`[ADDR]`	`1 to 6`	Address of module corresponding to controller slot. *Address 1 = Slot 1 = the module on the leftmost position as seen from front of the cabinet.*
`[CH]`	`1 to 3`	Specific channel of a Module. Only applicable for modules with multiple input or output channels.
`[DF]`	`0.1 to 3.0`	Drive factor (numerical values only). In normal operating conditions, set this value to 1 (or 1.0).
`[DIR]`	`0 to 1`	Direction of movement: set to 1 for positive movement and 0 (zero) for negative movement[4].
`[FREQ] or [FREQx]`	`1 to 600`	Step frequency input. Value is in Hertz [Hz] (numerical values only). *The `FREQ` / `FREQx` parameter can be set from 1 to 600 [Hz], but depending on the `STAGE`, a maximum value of 600 is not always the most efficient value. For example, when using CLA-type actuators it is best to set this value to 600, but for CBS-type actuators a more optimal performance can be reached when using a maximum step frequency in the region of 300 [Hz] to 450 [Hz]. Also note that any load on the actuator can have an impact on this, so it is best to have a pragmatic approach to determine an optimal value.*

[4] Consult the Interface Drawing of the particular actuator or system for the definition of positive- and negative movement.

Parameter	Value	Description
[RSS]	1 to 100	(Relative) actuator step size parameter input. Value is a percentage [%] (numerical values only)[5].
[STAGE]	{VARIOUS}	Sets specific internal drive parameters for the type of actuator or system attached to that particular channel of that particular module set by [ADDR] and [CH]. Use command /STAGES to get list of the available options.
[STEPS]	0 to 50000	Number of actuation steps. Range 0 to 50000, where 0 is used for infinite move (use STP command to stop actuator movement).
[TEMP]	0 to 300	Set this parameter to the temperature of the environment in which the actuator is used. Input is in Kelvin [K] (numerical values only).

4.4 Administrative CLI commands

4.4.1 MODLIST – Get information about installed modules

This command will return a (comma-separated) list of all detected modules in the controller. If no (or unknown) module is installed, a dash (-) will be returned.

Command [followed by enter]	cacli MODLIST
Response (example)	CADM2,RSM,-,-,-,-,

4.4.2 IPR – Read IP settings from controller

This command will return (a command separated decimal list of) IP settings stored in the controller. Useful to determine the controller's network settings prior to connecting the controller to a LAN.

Command [followed by enter]	cacli IPR
Response (definition)	[DHCP],[IP Octets 1-4],[Subnet Octets 1-4],[Gateway Octets 1-4],[MAC Address Octets 1-6]
Response (example)	1,192,168,15,40,255,255,255,0,192,168,15,125,12,22,32,42,52,62

4.4.3 IPS – Configure IP settings for controller

Command to set IP network parameters for the controller to be connected to a LAN. With this command it is possible to enable DHCP mode or to set an IP address, Subnet Mask and Gateway address manually (if DHCP is disabled / not available).

Command [followed by enter]	cacli IPS [DHCP] [IP Octets 1-4] [Subnet Octets 1-4] [Gateway Octet 1-4]
Command (example)	DHCP (IP, Subnet Mask and Gateway can be left zero): cacli IPS 1 0 0 0 0 0 0 0 0 0 0 0 Manual IP: cacli IPS 0 192 168 15 40 255 255 255 0 192 168 15 125

[5] *See product brochures for typical step size values for each actuator or system. Typically leave this at 100[%] unless small(er) steps are required.*

Response (example)	IP information set.

4.4.4 /STAGES – List of supported actuator and stage types

For use as reference for the [STAGE] parameter, this command will return a (comma-separated) list of all supported actuators and stages.

Command [followed by enter]	cacli /STAGES
Response (example)	CLA2201,CLA2201-COE,CLA2201MK1,CLA2201MK1-COE,CLA2601,CLA2601-COE,CLA2601MK1,CLA2601MK1-COE,CPSHR1-S,CPSHR2,CPSHR2-S,CPSHR2-COE,CPSHR2-S-COE,CPSHR3,CPSHR3-S,CPSHR3-COE,CPSHR3-S-COE,CBS10,CBS10-RLS,CBS5,CBS5-RLS,CS021.X,CS021.Y,CS021.Z,CS021-RLS.X,CS021-RLS.Y,CS021-RLS.Z,CTS1,CTS2,CLD1,CLD1-COE,CTTPS1/2,CTTPS1,CRM1,CRM1-COE

4.4.5 /LAN – Scan for LAN connected controllers

If one or more controllers are connected to a Local Area Network (LAN), use this command to retrieve a (comma-separated) list of connected devices with their respective IP-addresses. If none found, a 'no controller connected'- message will be displayed.

Command [followed by enter]	cacli /LAN
Response (example)	192.168.15.40

4.4.6 /USB – Scan for USB connected controllers

If multiple controllers are connected to a PC using USB, use this command to retrieve a (comma-separated) list of connected devices. If none found, a 'no controller connected'- message will be displayed.

Command [followed by enter]	cacli /USB
Response (example)	1038E201807-05

4.4.7 /VER – Get CLI version information

Command [followed by enter]	cacli /VER
Response (example)	7.2.20201015

4.4.8 FIV – Get Firmware version information

Request the firmware version of each installed module on [addr]. [addr] can be set from 0 to 6, where 0 corresponds to the PCI2 module at the back of the controller, and 1 – 6 corresponds to Slot1 – Slot6.

Command [followed by enter]	cacli FIV [ADDR]
Command (example)	cacli FIV 0
Response (example)	PCI.6.0.20190715

4.4.9 FU – Firmware update

Command to update cabinet and/or module firmware[6]. `[addr]` can be set from 0 to 6, where 0 corresponds to the PCI2 module at the back of the controller (USB/LAN connection), and 1 – 6 corresponds to Slot1 – Slot6.

Command [followed by enter]	`cacli FU [ADDR] [Path to binary file]`
Command (example)	`cacli FU 1 D:\Cadm2Firmware.bin`
Response (example)	`Firmware update complete.`

4.5 CADM2 specific commands

4.5.1 DESC – Get information on installed module

Requests the module description and available output channels

Command [followed by enter]	`cacli DESC [ADDR]`
Command (example)	`cacli DESC 1`
Response (example)	`1, CADM2`

4.5.2 GFS – Request fail safe state

Requests the fail-safe state of the CADM2 module. If any error occurred (red status LED on module front panel has been lit), the cause of the error may be requested via this command. Please see paragraph 4.11 for specific details about the safe state responses.

Command [followed by enter]	`cacli GFS [ADDR]`
Command (example)	`cacli GFS 1`

Response (example)	`0,ERROR CODE: 0`
	
	`NO ERRORS PRESENT.`

4.5.3 MOV – Move

Note: command specific for Basedrive mode of operation.

The move command starts moving an actuator with specified parameters. If an RSM or OEM2 is installed, the actuator position will be tracked automatically if the actuator is fitted with a Resistive Linear Sensor (-RLS option) or Cryo Optical Encoder (-COE option) and connected to one of the channels of the RSM or OEM2 module.

Command [foll. by enter]	`cacli MOV [ADDR] [DIR] [FREQ] [RSS] [STEPS] [TEMP] [STAGE] [DF]`
Command (example)	`cacli MOV 1 1 600 100 0 293 CLA2601 1`
Response (example)	`Actuating the stage.`

Please note the following:

[6] To request information on available firmware updates, please fill in the contact form on www.jpe-innovations.com/contact and provide the Controller ID code.

- *When active, the (blue) Output Active LED on the CADM2 will be ON continuously.*
- *Use the Stop command (`STP`) to stop the current movement. If `[STEPS]` is set to a value other than zero, the actuator will be stopped automatically after completing the set number of steps.*
- *Avoid physically touching unconnected outputs when the controller is turned ON.*
- *Power down the controller before disconnecting or reconnecting any actuator(s) or system(s).*
- *OEM2 Encoder values will be reset after a power cycle (the Cryo Optical Encoder is a relative incremental encoder; current positions will not be stored).*

4.5.4 STP – Stop

Note: command specific for Basedrive mode of operation.

Stops movement of an actuator (`MOV` command), disables external input mode (`EXT` command) or disables scan mode (`SDC` command).

Command [followed by enter]	cacli STP [ADDR]
Command (example)	cacli STP 1
Response (example)	Stopping the stage.

4.5.5 SDC – Scan Mode

Note: command specific for Basedrive mode of operation.

The CADM2 can be used in a "scan mode". In this mode the module will output a DC voltage level (to be used with a scanner piezo for example) instead of the default drive signal. `[VALUE]` can be set to a numerical value in between 0 and 1023 (10-bit value) where zero represents ~0[V] output (-30[V] in respect to REF) and the maximum value represents ~150[V] output (+120[V] in respect to REF).

Command [followed by enter]	cacli SDC [ADDR] [VALUE]
Command (example)	cacli SDC 1 512
Response (example)	Scan mode enabled.

Please note the following:

- *When active, the (blue) Output Active LED on the CADM2 will BLINK.*
- *Use the Stop command (`STP`) to disable this mode.*
- *Avoid physically touching unconnected outputs when the controller is turned ON.*
- *Power down the controller before disconnecting or reconnecting any actuator(s) or system(s).*

4.5.6 EXT – Use External Input

Note: command specific for Flexdrive mode of operation.

To use the CADM2 in Flexdrive mode, it is required to set the module in external (analog) input mode prior to using Flexdrive. The `EXT` command basically works similar to the `MOV` command, however there are a few differences:

- The [FREQ] argument now defines the step frequency at maximum (absolute) input signal. By default, set this to 600 [Hz].
- With the [DIR] argument it is possible to reverse the input direction of movement relation. By default, this parameter is set to 1 so that a positive input voltage results in a positive movement.

Command [followed by enter]	cacli EXT [ADDR] [DIR] [FREQ] [RSS] [TEMP] [STAGE] [DF]
Command (example)	cacli EXT 1 1 600 100 293 CLA2601 1
Response (example)	External mode enabled.

Please note that the relative actuator step size needs to be set within the EXT command! If a different step size is required in Flexdrive mode, this command needs to be executed again with a different [RSS] value! The external (analog) input only directs Frequency and Direction (positive/negative) of movement.

Note that the CADM2 module will perform an 'automatic zero calibration' upon power on to make sure the connected actuator will not move at an input voltage of 0 (zero) [V]. However, this means that it is required to hold the input at 0 (zero) [V] while booting the controller (do not let the input float).

Also be aware of:

- *When active, the (blue) Output Active LED on the CADM2 will be ON continuously.*
- *Use the Stop command (STP) to disable this mode.*
- *Avoid physically touching unconnected outputs when the controller is turned ON.*
- *Power down the controller before disconnecting or reconnecting any actuator(s) or system(s).*
- *OEM2 Encoder values will be reset after a power cycle (the Cryo Optical Encoder is a relative incremental encoder; current positions will not be stored).*

4.6 RSM specific commands

4.6.1 PGV – Get current position

Note: command specific for Basedrive mode of operation.

Request the position of a Resistive Linear Sensor (RLS) connected to a specific channel [CH] of the RSM module. Return value is in [m].

Command [followed by enter]	cacli PGV [ADDR] [CH] [STAGE]
Command (example)	cacli PGV 2 1 CBS10-RLS
Response (example)	-0.003289070

4.6.2 PGVA – Get current position of all 3 channels

Note: command specific for Basedrive mode of operation.

Request the position of all three channels of the RSM simultaneously. Return values are in [m] (comma separated).

Command [followed by enter]	cacli PGVA [ADDR] [STAGE] [STAGE] [STAGE]
Command (example)	cacli PGVA 2 CBS10-RLS CBS10-RLS CBS10-RLS

Response (example)	-0.003289097,-0.000879089,0.226116203

4.6.3 MIS – Set negative end stop

Note: command specific for Basedrive mode of operation. To be used as part of the RLS Calibration process (see paragraph 4.6.11).

Set the current position of a Resistive Linear Sensor (RLS) connected to channel `[CH]` of the RSM to be the negative end-stop. Please follow the RLS Calibration process on how and when to use this command correctly.

Command [followed by enter]	cacli MIS [ADDR] [CH]
Command (example)	cacli MIS 2 1
Response (example)	Minimum position set.

4.6.4 MAS – Set positive end stop

Note: command specific for Basedrive mode of operation. To be used as part of the RLS Calibration process (see paragraph 4.6.11).

Set the current position of a Resistive Linear Sensor (RLS) connected to channel `[CH]` of the RSM to be the positive end-stop. Please follow the RLS Calibration process on how and when to use this command correctly.

Command [followed by enter]	cacli MAS [ADDR] [CH]
Command (example)	cacli MAS 2 1
Response (example)	Maximum position set.

4.6.5 MIR – Read negative end stop

Note: command specific for Basedrive mode of operation.

Read the current value of the negative end-stop parameter set for a specific channel `[CH]` of an RSM. Response value in in [m].

Command [followed by enter]	cacli MIR [ADDR] [CH] [STAGE]
Command (example)	cacli MIR 2 1 CBS10-RLS
Response (example)	-0.004854101

4.6.6 MAR – Read positive end stop

Note: command specific for Basedrive mode of operation.

Read the current value of the positive end-stop parameter set for a specific channel `[CH]` of an RSM. Response value is in [m].

Command [followed by enter]	cacli MAR [ADDR] [CH] [STAGE]
Command (example)	cacli MAR 2 1 CBS10-RLS

Response (example)	0.004864049

4.6.7 MMR – Reset negative and positive end stop

Note: command specific for Basedrive mode of operation.

Reset the current values of the negative and positive end-stop parameters set for a specific channel [CH] of an RSM. Note that both parameters will be reset to the values stored in the non-volatile memory of the controller (see paragraph 4.6.10).

Command [followed by enter]	cacli MMR [ADDR] [CH]
Command (example)	cacli MMR 2 1
Response (example)	Minimum and maximum position reset.

4.6.8 EXS – Set excitation duty cycle

Note: command specific for Basedrive mode of operation.

Set the duty cycle of the sensor excitation signal of the RSM. A lower duty cycle reduces the amount of power dissipated in the sensors, while a higher value provides a higher resolution. Value is in [%] and can be set to 0 (zero) or from 10 to (default) 100. The duty cycle is set for all channels of an RSM module (it is not possible to set the duty cycle for an individual channel).

Command [followed by enter]	cacli EXS [ADDR] [DUTY]
Command (example)	cacli EXS 2 100
Response (example)	Excitation duty cycle set.

4.6.9 EXR – Read excitation duty cycle

Note: command specific for Basedrive mode of operation.

Read the duty cycle of the sensor excitation signal of the RSM. Response value is in [%]. The duty cycle is set equally for all channels of an RSM module.

Command [followed by enter]	cacli EXR [ADDR]
Command (example)	cacli EXR 2
Response (example)	100

4.6.10 RSS – Save settings to non-volatile memory

Note: command specific for Basedrive mode of operation.

Store the current values of the following parameters of the RSM to the non-volatile memory of the controller: *excitation duty cycle* (EXS), *negative end stop* (MIS) and *positive end-stop* (MAS).

Command [followed by enter]	cacli RSS [ADDR]
Command (example)	cacli RSS 2
Response (example)	Settings stored in flash.

Note that when resetting the negative and positive end stop values (see paragraph 4.6.7), these settings will be (re-)loaded. Also note that any previously stored values will be overwritten.

Factory default settings are:
- *EXS: 100%*
- *MIS and MAS: factory calibrated values for the ordered actuator or system.*

4.6.11 How to calibrate a Resistive Linear Sensor (RLS)

Follow the instructions below to (re-)calibrate a Resistive Linear Sensor (RLS) connected to one of the sensor inputs of an RSM using the commands listed in previous paragraphs.

1 Make sure the actuator is not moving. Run the MIR (see paragraph 4.6.5) and MAR (see paragraph 4.6.6) command to get the current values stored in the controller for the negative and positive end stop respectively. Write these values down in case it is required to restore these values.

2 Move the connected actuator to the negative end stop position. This can be done manually *(with great care and only if physically possible)* or by using the MOV command (see paragraph 4.5.3). When using the MOV command, use the PGV (see paragraph 4.6.1) or PGVA command (see paragraph 4.6.2) to determine when the negative end stop position has been reached (position value should not change at end stop).

3 Make sure the actuator is not moving. Use the MIS command (see paragraph 4.6.3) to set the current position value to be the negative end stop.

4 Move the connected actuator to the positive end stop position. This can be done manually *(with great care and only if physically possible)* or by using the MOV command (see paragraph 4.5.3). When using the MOV command, use the PGV (see paragraph 4.6.1) or PGVA command (see paragraph 4.6.2) to determine when the positive end stop position has been reached.

5 Make sure the actuator is not moving. Use the MAS command (see paragraph 4.6.4) to set the current position value to be the positive end stop.

6 Save the calibration values to the non-volatile memory using the RSS command (see paragraph 4.6.10) so they will be stored even if the controller has been powered down.

7 Repeat steps #1 to #6 for any other sensors connected to the RSM to complete the (re-)calibration.

4.7 OEM2 specific commands

4.7.1 CGV – Get current counter value

Note: command specific for Basedrive mode of operation.

Request the counter value of a Cryo Optical Encoder (COE) connected to a specific channel `[CH]` of the OEM2 module. Return value is in [counter ticks][7].

Command [followed by enter]	cacli CGV [ADDR] [CH]
Command (example)	cacli CGV 4 1
Response (example)	42

Counter values will be reset after a power cycle (the Cryo Optical Encoder is a relative incremental encoder; current positions will not be stored).

4.7.2 CSZ – Reset current counter value to zero

Note: command specific for Basedrive mode of operation.

Resets the counter (to zero) for a specific Cryo Optical Encoder connected (COE) to a specific channel `[CH]` of the OEM2 module.

Command [followed by enter]	cacli CSZ [ADDR] [CH]
Command (example)	cacli CSZ 4 1
Response (example)	Position counter set to 0.

4.7.3 DGV – Get current encoder signal value

Note: command specific for Basedrive mode of operation.

Request the (raw) encoder signal value of a Cryo Optical Encoder (COE) connected to a specific channel `[CH]` of the OEM2 module. Return value is a unitless number between [0] and [255].

Command [followed by enter]	cacli DGV [ADDR] [CH]
Command (example)	cacli DGV 4 1
Response (example)	228

Typically (only) useful in case an encoder does not seem to count properly. If that is the case, it is useful to drive the actuator at a low frequency (~ 5 [Hz]) and to log the (raw) encoder signal values using the DGV command.
When plotted, the graph should display a sine or square wave-like signal with maximum values (significantly) above the Upper Threshold Value (DSH command) and minimum values (significantly)

[7] The OEM2 encoder position readout is displayed in Encoder Ticks (counter pulses). Position resolution depends on type of encoder grid (defined as PPR, Pulses Per Revolution - see brochures of each individual product).

lower than the Lower Threshold Value (DSL command). If that is not the case, one culprit may be particles blocking the encoder grid slots for example.

4.7.4 OEMC – Automatic Optical Encoder Module Calibration

Note: command specific for Basedrive mode of operation.

Only to be used when there is an issue with a Cryo Optical Encoder (COE) or OEM2 module or if the Cryo Optical Encoder requires re-calibration. Before executing this command, make sure to run the MLS command first (see paragraph 4.7.5) and take a note of the current calibrated values (so these can be restored if necessary).

Command to initiate an automatic calibration procedure for a specific Cryo Optical Encoder (COE) connected to channel `[CH]` of an OEM2. The `[STAGE]` must be connected to the CADM2 module installed on `[CADM2 ADDR]` **and the actuator must be able to move freely (!)**. The calibration function normally takes about 15-30 seconds to complete.

Command [followed by enter]	`cacli OEMC [ADDR] [CH] [CADM2 ADDR] [TEMP] [STAGE]`
Command (example)	`cacli OEMC 4 1 1 293 CLA2201-COE`
Response (example)	`Channel calibrated.`

4.7.5 MLS – Request calibration values

Note: command specific for Basedrive mode of operation.

Request the Detector Gain setting `[GAIN]`, Upper Threshold value `[UT]` and Lower Threshold value `[LT]` set to a specific channel `[CH]` of the OEM2 module. Return value is a comma-separated list of unitless values in between [1] and [255].

Command [followed by enter]	`cacli MLS [ADDR] [CH]`
Command (example)	`cacli MLS 4 1`
Response	`[GAIN],[UT],[LT]`
Response (example)	`5,164,82`

4.7.6 DSG – Set detector gain

Note: command specific for Basedrive mode of operation.

Command to set a Detector Gain `[GAIN]` for a specific channel `[CH]` of the OEM2 module, where `[GAIN]` can have a value in between [1] and [255]. Make sure to run the MSS command to store settings in the controller memory (see paragraph 4.7.9).

Command [followed by enter]	`cacli DSG [ADDR] [CH] [GAIN]`
Command (example)	`cacli DGV 4 1 10`
Response (example)	`Detector gain set.`

An optimal gain value will depend on the connected actuator or stage, but in general a low(er) value should already gain an excellent signal quality. Typically gain is set in between 5 and 15. See also DGV command (paragraph 4.7.3)

4.7.7 DSH – Set upper threshold value

Note: command specific for Basedrive mode of operation.

Command to set a Detector Upper Threshold value `[UT]` for a specific channel `[CH]` of the OEM2 module, where `[UT]` can have a value in between [1] and [255] and must be set to a higher value than the Lower Threshold value `[LT]` (see paragraph 4.7.8). Make sure to run the MSS command to store settings in the controller memory (see paragraph 4.7.9).

Command [followed by enter]	cacli DSH [ADDR] [CH] [UT]
Command (example)	cacli DSH 4 1 180
Response (example)	Detector upper threshold set.

An optimal upper threshold value will depend on the connected actuator or stage, but in general a value of around 160 to 180 is suitable for must products. Another rule of thumb is to set `[UT]` to a value of around `[DGV(max)]-60`. See also DGV command (paragraph 4.7.3)

4.7.8 DSL – Set lower threshold value

Note: command specific for Basedrive mode of operation.

Command to set a Detector Lower Threshold value `[LT]` for a specific channel `[CH]` of the OEM2 module, where `[UT]` can have a value in between [1] and [255] and must be set to a lower value than the Upper Threshold value `[UT]` (see paragraph 4.7.7). Make sure to run the MSS command to store settings in the controller memory (see paragraph 4.7.9).

Command [followed by enter]	cacli DSL [ADDR] [CH] [UT]
Command (example)	cacli DSL 4 1 60
Response (example)	Detector lower threshold set.

An optimal lower threshold value will depend on the connected actuator or stage, but in general a value of around 40 to 60 is suitable for must products. Another rule of thumb is to set `[LT]` to a value of around `[DGV(min)]+60`. See also DGV command (paragraph 4.7.3)

4.7.9 MSS – Store calibration values to nonvolatile memory

Note: command specific for Basedrive mode of operation.

Once detector settings (gain and/or both threshold values) have been changed, use this command to store these values in nonvolatile memory so that these values will be reloaded after a power cycle. Note that with this command, settings for all 3 channels of the OEM2 will be stored.

Command [followed by enter]	cacli MSS [ADDR]

Command (example)	cacli MSS 4
Response (example)	Detector settings stored in flash.

4.8 EDM specific commands

4.8.1 EGC – Request current state of all Interrupter Channels

Note: command specific for Basedrive mode of operation.

Request the current state of all photo interrupter channels of an EDM on address `[ADDR]`. Return value is a comma-separated list of Booleans. When active state set to the default state (active high, see 4.8.9), the return value will be 0 (zero) if the connected sensor is not being interrupted or 1 if the connected sensor is being interrupted (i.e. obstacle detected by photo interrupter).

Command [followed by enter]	cacli EGC [ADDR]
Command (example)	cacli EGC 2
Response	[CH1],[CH2],[CH3],[CH4],[CH5],[CH6]
Response (example)	0,0,1,1,0,1

4.8.2 EGCL – Request latched state of all Interrupter Channels

Note: command specific for Basedrive mode of operation.

Request the latched state of all photo interrupter channels of an EDM on address `[ADDR]`. Return value is a comma-separated list of Booleans. When active state set to the default state (active high, see 4.8.9), the return value will be 0 (zero) if the connected sensor has not been interrupted or 1 if it has been interrupted (i.e. obstacle detected by photo interrupter).

Note that once triggered (i.e. sensor has been in interrupted), the latched state will remain true until read, so after sending the EGCL command, the latched stated will be reset.

Command [followed by enter]	cacli EGCL [ADDR]
Command (example)	cacli EGCL 2
Response	[CH1],[CH2],[CH3],[CH4],[CH5],[CH6]
Response (example)	1,1,0,0,1,0

4.8.3 EGV – Request current signal strength of a single Interrupter Channel

Note: command specific for Basedrive mode of operation.

Request the current signal strength of a single photo interrupter channel `[CH]` of an EDM on address `[ADDR]`. Return value is a `[decimal number]` in between 0 and 65535 (16 bits).

Command [followed by enter]	cacli EGV [ADDR] [CH]
Command (example)	cacli EGV 2 4
Response (example)	3087

4.8.4 EGVA – Request current signal strength of all Interrupter Channels

Note: command specific for Basedrive mode of operation.

Request the current signal strength of all photo interrupter channels [CHx] of an EDM on address [ADDR]. Return value is a comma-separated list of [decimal numbers] in between 0 and 65535 (16 bits).

Command [followed by enter]	cacli EGVA [ADDR]
Command (example)	cacli EGVA 2
Response	[CH1],[CH2],[CH3],[CH4],[CH5],[CH6]
Response (example)	61312,60239,60942,3087,61851,59976

4.8.5 EGE – Request current state of all External Digital Inputs

Note: command specific for Basedrive mode of operation.

Request the current state of all external digital inputs [DIx] of an EDM on address [ADDR]. Return value is a comma-separated list of Booleans. All digital inputs are active high.

Command [followed by enter]	cacli EGE [ADDR]
Command (example)	cacli EGE 2
Response	[DI1],[DI2],[DI3],[DI4],[DI5],[DI6]
Response (example)	0,1,0,0,0,1,0,0

4.8.6 EGVE – Request current signal value of all External Analog Inputs

Note: command specific for Basedrive mode of operation.

Request the current signal value of all external analog inputs [AIx] of an EDM on address [ADDR]. Return value is a comma-separated list of values in [Volt] (16bit resolution, in range 0 to 5.000).

Command [followed by enter]	cacli EGVE [ADDR]
Command (example)	cacli EGVE 2
Response	[AI1],[AI2],[AI3]
Response (example)	2.500,0.001,0.100

4.8.7 MLC – Request gain and threshold values of a single Interrupter Channel

Note: command specific for Basedrive mode of operation.

Request [GAIN], upper threshold [UT] and lower threshold [LT] of a single photo interrupter channel [CH] of an EDM on address [ADDR]. Return value is a comma-separated list of decimal values.

Command [followed by enter]	cacli MLC [ADDR] [CH]
Command (example)	cacli MLC 2 1
Response	[GAIN],[UT],[LT]
Response (example)	255,200,100

4.8.8 MLG – Request power setting and active state of all Interrupter Channels

Note: command specific for Basedrive mode of operation.

Request `[DUTY CYCLE]` and `[ACTIVE STATE]` for all photo interrupter channels of an EDM on address `[ADDR]`. Duty cycle return value is in per mille (‰), active state return value is a Boolean.

Command [followed by enter]	cacli MLG [ADDR]
Command (example)	cacli MLG 2
Response	[DUTY CYCLE],[ACTIVE STATE]
Response (example)	1000,1

4.8.9 EIN – Set active state of all Interrupter Channels

Note: command specific for Basedrive mode of operation.

Command to set the active state `[STATE]` of all photo interrupter channels of an EDM on address `[ADDR]` to either `0` (active low) or `1` (active high, default).

Command [followed by enter]	cacli EIN [ADDR] [STATE]
Command (example)	cacli EIN 2 1
Response (example)	Endswitch active state set.

4.8.10 SID – Set signal power of all Interrupter Channels

Note: command specific for Basedrive mode of operation.

Command to set the signal `[DUTY CYCLE]` of all photo interrupter channels of and EDM on address `[ADDR]`. The duty cycle value can range from 51 to 1000 (value in per mille, ‰). The default value is 500 ‰.

Command [followed by enter]	cacli SID [ADDR] [DUTY CYCLE]
Command (example)	cacli SID 500
Response (example)	Endswitch duty cycle set.

Please note that there are also a couple of preset values available that can be set with the commands `LDI` (see 4.8.14), `LMI` (see 4.8.15) and `LMA` (see 4.8.16).

4.8.11 SIG – Set gain of a single Interrupter Channel

Note: command specific for Basedrive mode of operation.

Command to set the signal `[GAIN]` of a single photo interrupter channel `[CHx]` of and EDM on address `[ADDR]`. The gain value can range from 1 to 255 (default value).

Command [followed by enter]	cacli SIG [ADDR] [CH] [GAIN]
Command (example)	cacli SIG 2 1 255

Response (example)	Endswitch gain set.

4.8.12 SHT – Set upper threshold value of a single Interrupter Channel

Note: command specific for Basedrive mode of operation.

Command to set the upper threshold `[UT]` of a single photo interrupter channel `[CH]` of an EDM on address `[ADDR]`. The upper threshold can range from 0 to 255 (default value is 200).

Command [followed by enter]	cacli SHT [ADDR] [CH] [UT]
Command (example)	cacli SHT 2 1 200
Response (example)	Endswitch upper threshold set.

4.8.13 SLT – Set lower threshold value of a single Interrupter Channel

Note: command specific for Basedrive mode of operation.

Command to set the lower threshold `[LT]` of a single photo interrupter channel `[CH]` of an EDM on address `[ADDR]`. The lower threshold can range from 0 to 255 (default value is 100).

Command [followed by enter]	cacli SLT [ADDR] [CH] [UT]
Command (example)	cacli SLT 2 1 100
Response (example)	Endswitch lower threshold set.

4.8.14 LDI – Turns signal power for all Interrupter Channels OFF

Note: command specific for Basedrive mode of operation.

Command to turn the signal power off for all photo interrupter channels connected to an EDM on address `[ADDR]`.

Command [followed by enter]	cacli LDI [ADDR]
Command (example)	cacli LDI 2
Response (example)	Endswitch power turned off.

This is useful for when it is absolutely necessary to limit any dissipation (on the photo interrupter / endswitch side), without having to disconnect the photo interrupters).

4.8.15 LMI – Turns signal power for all Interrupter Channel to MIN

Note: command specific for Basedrive mode of operation.

Command to turn the signal power for all photo interrupter channels connected to an EDM on address `[ADDR]` to the minimum duty cycle for normal operation.

Command [followed by enter]	cacli LMI [ADDR]
Command (example)	cacli LMI 2

Response (example)	Endswitch power set to minimum.

4.8.16 LMA – Turns signal power for all Interrupter Channels to MAX

Note: command specific for Basedrive mode of operation.

Command to turn the signal power for all photo interrupter channels connected to an EDM on address `[ADDR]` to the maximum duty cycle (100% - basically "always ON") for normal operation.

Command [followed by enter]	cacli LMA [ADDR]
Command (example)	cacli LMA 2
Response (example)	Endswitch power set to maximum.

4.8.17 MSF – Store all settings to nonvolatile memory

Note: command specific for Basedrive mode of operation.

Once settings have been changed, use this command to store these values in nonvolatile memory so that these values will be reloaded after a power cycle. Note that with this command, settings for all channels of the EDM will be stored.

Command [followed by enter]	cacli MSF [ADDR]
Command (example)	cacli MSF 2
Response (example)	Settings stored in flash.

4.9 Servodrive specific commands

Once Servodrive mode has been enabled, do not use other non-Servodrive commands (for example do not use the `MOV` command while in Servodrive mode). In general, Servodrive commands are 4-characters long starting with the letters `FB`.

4.9.1 How Servodrive control loop works

Servodrive uses an internal position feedback control to address multiple (position) setpoints per controller (closed-loop). This requires the Optical Encoder Module (OEM2) or Resistive Sensor Module (RSM) installed and is only available as function of the CLI.

Note that Servodrive supports up to 3 actuators in closed-loop per controller cabinet! If more axes are to be used in Servodrive mode, additional cabinets are required.

After enabling Servodrive, the basic movement sequence[8] is:

1 Start moving with a given *step frequency* and 100% *step size* towards the setpoint. The step frequency is proportional to the setpoint error. This means that when the error gets smaller (=

[8] This control loop profile is chosen for the sole reason that this is most reliable and robust when operating an actuator in any kind of environment (ambient, vacuum, cryogenic).

closer to setpoint), the step frequency will be reduced. Near the setpoint, the actuator will be stepping with a ~1Hz frequency.

2 When the actuator crosses the setpoint (overshoot), the controller reverses the direction of movement and continues with a reduced *step size* (50%).

3 When the actuator crosses the setpoint again, the control loop will stop and set the status to "Finished". In practice this means that the actuator will be within one piezo stroke of the setpoint. If required, switch to Scan mode (see paragraph 4.5.5) to do fine positioning.

4 Should the actuator not be able to reach the given setpoint, a 10 second time-out will trigger the control loop to stop. Note that this time-out can only happen at step #2 of the movement profile.

4.9.2 FBEN – Enable Servodrive

Enable the internal position feedback control and start operating in servo mode with the connected `[STAGE]` and a given initial (maximum) step frequency `[FREQx]`.

Command [followed by enter]	`cacli FBEN [STAGE1] [FREQ1] [STAGE2] [FREQ2] [STAGE3] [FREQ3] [DF] [TEMP]`
Command (example)	`cacli FBEN CBS10-RLS 300 CBS10-RLS 300 CBS10-RLS 300 1 293`
Response (example)	`Control loop enabled.`

4.9.3 FBXT – Disable Servodrive

Disable the internal position feedback control.

Command [followed by enter]	`cacli FBXT`
Response (example)	`Control loop disabled.`

4.9.4 FBCS – Go to setpoint

When Servodrive has been enabled (`FBEN`) use this command to move actuators to a set point position. After the `FBCS` command has been send, the controller will react immediately by moving the actuators towards the set points `[SP1]`, `[SP2]` and `[SP3]`.

For linear type actuators (for example CBS, CLA), `[SPx]` values need to be entered in [m]. For rotational type actuators (for example CRM), `[SPx]` values need to be entered in [rad].

Set `[ABS]` to 1 to enable absolute positioning, otherwise set to 0 (zero). Depending on the sensor used, absolute and relative positions are defined as:

- When using RLS / RSM: absolute positioning is relative to the center of the stage, whereas relative positioning is relative to the current position.
- When using COE / OEM2: absolute positioning is relative to count 0 (zero)[9], whereas relative positioning is relative to the current count value.

[9] Count 0 can mean two things: A) position at power on, or B) position after executing the CSZ command (which is not recommended to do while in Servodrive mode)

Command [followed by enter]	cacli FBCS [SP1] [ABS] [SP2] [ABS] [SP3] [ABS]
Command (example, SP in [m])	cacli FBCS -1e-3 0 1e-3 1 1.23e-4 1
Command (example, SP in [rad])	cacli FBCS 6.28 0 0 0 0 0
Response (example)	Control loop setpoints set.

Note that if there is no actuator / stage is connected to one of the outputs, enter 0 (zero) as position set point.

Please note the following:

- *Avoid physically touching unconnected outputs when the controller is turned ON.*
- *Power down the controller before disconnecting any actuator(s) or system(s).*

4.9.5 FBES – Emergency stop

When Servodrive has been enabled and actuators are moving use this command for an immediate stop (of all actuators). The control loop will be aborted and the actuators will stop at their current location.

Command [followed by enter]	cacli FBES
Response (example)	Control loop emergency stop enabled.

4.9.6 FBST – Get status position control

This command returns a (comma-separated) list with status and position error information.

Command [followed by enter]	cacli FBST
Response	[ENABLED] [FINISHED] [INVALID SP1] [INVALID SP2] [INVALID SP3] [POS ERROR1] [POS ERROR2] [POS ERROR3]
Response (example)	1 0 0 0 0 -8528 -11864 42770

Parameter	Description
[ENABLED]	0 : position control is disabled. 1 : position control is enabled.
[FINISHED]	0 : controller is moving the [STAGE] towards setpoint [SPx]. 1 : controller has completed most recent positioning sequence.
[INVALID SPx]	0 : entered setpoint is valid. 1 : entered setpoint is not within range of the stage[10].
[POS ERRORx]	Position error value in [bits]. Mainly used to confirm (correct) direction of movement of [stage]. In normal operation this value should change towards zero while moving actuators towards a set point.

[10] Range is defined by positive and negative end stop values, set for that particular input channel [ch] of the RSM, see paragraphs 4.6.5 & 4.6.6.

Poll the `[FINISHED]` parameter of the status command to know if an actuator is still moving or at its set position. It is up to the higher-level user software to determine and/or implement time-outs (if required).

4.10 Command error codes

In case the controller receives an invalid command, an error response will be sent back accompanied by an error description in the following format: `[Error, description]`.

Description	Possible solutions
`One or more arguments are invalid`	Check the values of each parameter. Most likely there is a typo or a value has been set out of range.
`Incorrect number of arguments`	Indicates that the parameter argument string is not complete; for example, if the following command is sent: `MOV 1 0 CLA2601`, the controller system will respond with this error (because the `MOV` parameter requires values for `FREQ, RSS, TEMP, STEPS` and `DF` as well).
`Stage axis is undefined`	Check the `STAGE` parameter. Some stage configurations require to define a specific axis as well. One example is the stage parameter for the CS021-RLS: in this case, the `STAGE` parameter needs to be `CS021-RLS.X`, `CS021-RLS.Y` or `CS021-RLS.Z` depending on the axis that is connected to a specific CADM2 output.
`Invalid stage name`	Check the `STAGE` parameter. Most likely there is a typo.
`[any decimal number]`	If these errors appear, first retry the command or reboot controller if that doesn't seem to solve the error. If the error codes are persistent, contact JPE for support.
`No Cryo Positioning Systems Controller could be found`	The controller is not connected to the PC. Check the USB or LAN connection. Check that if the controller is connected to LAN, the IP settings are correct (DHCP enabled, or when DHCP is disabled a valid IP address, subnet mask and gateway have been set). Reboot the controller.

4.11 Fail-safe State

When using the Fail-safe state command (GFS, see paragraph 4.5.2), the controller will display a Fail-safe State value. In normal operation this value should be `0 – NO ERRORS PRESENT`, however if there is an issue (amplifier status LED on front panel will light up red), the cause of the error may be requested via this command. The response will also give possible solutions and/or further checks to investigate the issue.

`NO ERRORS PRESENT.`
`ERROR: UPPER VOLTAGE RAIL IS MISSING` `INSPECTION OF UNIT IS REQUIRED`
`ERROR: LOWER VOLTAGE RAIL IS MISSING` `INSPECTION OF UNIT IS REQUIRED`

ERROR: THERMAL OVERLOAD OF AMPLIFIER STAGE LET UNIT COOL DOWN
ERROR: OVERCURRENT ON UPPER RAIL: I>10A t>100us: POSSIBLE CAUSES: 1) SHORT CIRCUIT TO PROTECTED EARTH OR REFERENCE 2) CAPACITIVE LOAD OR DRIVE PARAMETERS NOT CORRECT RESET IS REQUIRED
ERROR: OVERCURRENT ON UPPER RAIL: I>0.15A t>1ms: POSSIBLE CAUSES: 1) SHORT CIRCUIT TO PROTECTED EARTH OR REFERENCE 2) CAPACITIVE LOAD OR DRIVE PARAMETERS NOT CORRECT RESET REQUIRED
ERROR: OVERCURRENT ON LOWER RAIL: I>10A t>100us: POSSIBLE CAUSES: 1) SHORT CIRCUIT TO PROTECTIVE EARTH 2) CAPACITIVE LOAD OR DRIVE PARAMETERS NOT CORRECT RESET REQUIRED
ERROR: OVERCURRENT ON LOWER RAIL: I>0.15A t>1ms: POSSIBLE CAUSES: 1) SHORT CIRCUIT TO PROTECTIVE EARTH 2) CAPACITIVE LOAD OR DRIVE PARAMETERS NOT CORRECT RESET REQUIRED

5. GRAPHICAL USER INTERFACE (GUI)

***Important note**: A Graphical User Interface (GUI) for v7.x user software is in development, but not yet ready for release. Most functionality however is also present in the Command Line Interface (CLI).*

[11] CADM2, RSM and OEM2 modules are supported by the GUI.

[12] See CNP-Products MAN01-09 (CPSC).

6. TROUBLESHOOTING & KNOWN ISSUES

6.1 Unable to detect available channels

If the GUI or CLI is unable to find the available (CADM/CADM2/OEM2) channels, try the following:

1 Close the GUI or CLI application
2 Disconnect the USB and/or LAN cable
3 Power cycle the controller cabinet
4 Reconnect the USB and/or LAN cable
5 Start the GUI application or CLI again