

MAN02 – SOFTWARE USER MANUAL

## CRYO & NANO PRODUCTS

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## RELEVANT DOCUMENTATION

Ref	Title, Author
[1]	CNP_MANoo_Rxx_Getting-Started.pdf (JPE)
[2]	CNP_APNo2_Rxx_CPSC1-Modes-of-operation.pdf (JPE)
[3]	
[4]	
[5]	

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## DEFINITIONS



## ABBREVIATIONS

OS	Operating System

## 1. INTRODUCTION

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

This manual describes the control and operation of *Cryo & Nano Positioning Systems* (from here on described as systems) using JPE's cryogenic compatible positioners and actuators (from here on described as positioners and actuators).

These positioners and actuators can be operated by using a (modular) Controller System (from here on described as controller) which can be operated from a host system (from here on described as host) via commonly used digital interfaces.



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

*JPE shall not be liable for damage or injury resulting from misuse of the controller(s), positioner(s), actuator(s) and/or stage(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 firmware: **v8.o.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Please note that all content in this document is superseded by any new versions of this document.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](http://www.jpe-innovations.com)) to obtain the most recent version. 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 (MANoo) as well as the applicable Product User Manuals.*

## 2. HOST SYSTEM SETUP

To be able to communicate with the controller, a host must have at least one of the following commonly used digital interfaces available:

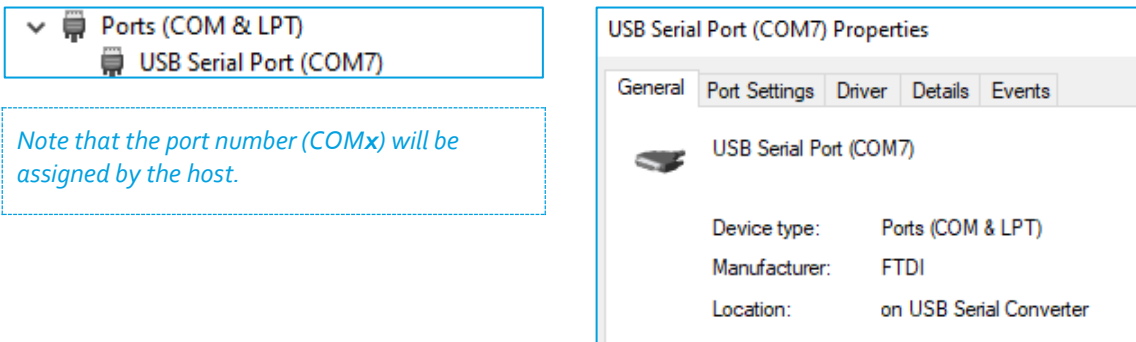
- USB Virtual COM port
- Ethernet (LAN)
- RS-422

Before connecting any cabling, make sure the *Mains Power Switch* on the back of the controller is in the "0" (OFF) position. After connecting the cabling, power on the cabinet by switching the *Mains Power Switch* to the "1" (ON) position.

### 2.1 USB Virtual COM port

This interface is recommended when using a regular computer or laptop (running Windows OS, Linux or MacOS for example) to operate the controller. Connect the supplied USB cable to the USB port on the back of the controller and to a free USB (2.0 or higher) port on the host.

The host should automatically recognize a (virtual) serial COM port. Using Windows 10 OS as an example, this will look something like this in the Windows *Device Manager*:



Note that the port number (COMx) will be assigned by the host.

Any general-purpose terminal program, like RealTerm or PuTTY, can be used to send commands to the controller and read responses from the controller. It is also possible to use software environments like NI LabVIEW®, MathWorks MATLAB®, EPICS or Python to open the COM port and to communicate with the controller.

By default the following settings must be used to open the (virtual) COM port:

Baudrate (Baud)	115200
Parity	None
Data bits	8
Stop bits	1
Hardware flow control	None
End Of Line (EOL)	CR & LF

*The Baudrate can be changed by using the command `/SBR` (see paragraph 4.4.7). To retrieve current settings use the `/GBR` command (see paragraph 4.4.6).*

## 2.2 Ethernet (LAN)

This interface is recommended if it is not possible to use USB ports on a company computer or laptop or when the host is physically not near the controller. Connect a standard CAT5e/CAT6 (or comparable) cable to the LAN port on the back of the controller and to a free network connection point on a Local Area Network (LAN).

By default DHCP is enabled, so that after connecting to a LAN the controller can get an IP address automatically<sup>1</sup>.

*Should the controller not be able to get an IP address via DHCP, it is possible to manual enter IP settings. In that case it is required to connect the controller via USB or RS-422 first to be able to change the IP settings in the controller using the `/IPS` command (see paragraph 4.4.5).*

*Likewise, use the `/IPR` command to retrieve the current IP settings stored in the controller (see paragraph 4.4.4).*

To connect to a controller via LAN, use the following default settings:

Hostname	cpsc1 <sup>2</sup> or use the IP address
Port	2000
Connection type	Raw
Optional	Implicit CR in every LF and/or implicit LF in every CR

## 2.3 RS-422

For industrial setups, PLCs or other stand-alone systems, communication through RS-422 is available on a 9p female D-Sub connector on the back of the controller.

*Please consult the CPSC1 Hardware User Manual (MAN01-14) for the pin out of this connector. General purpose 9p male D-Sub cables can be used to connect to this interface. It is also possible to use USB to RS422 converters, for example the Brainboxes US-320.*

By default the following settings must be used to open the RS-422 port:

Baudrate (Baud)	115200
Parity	None
Data bits	8
Stop bits	1
Hardware flow control	None
End Of Line (EOL)	CR & LF

*The Baudrate can be changed by using the command `/SBR` (see paragraph 4.4.7). To retrieve current settings use the `/GBR` command (see paragraph 4.4.6).*

<sup>1</sup> This requires a DHCP Server to be active on the Local Area Network (LAN).

<sup>2</sup> Note that all controllers will be named "cpsc1". In case multiple controllers are connected to the same LAN, use the IP address to connect to a specific controller.

## 2.4 Using multiple interfaces at the same time

Communicating with the controller is very flexible, but there is one strict ground-rule:

*A (new) command should be sent only after the response of the previous command has been received.*

In general, this will always be the case. An operator (or program running on the host) will send an instruction (command) to the controller and wait for the response to act on.

However, technically it is also possible to send command A via interface X (for example RS-422) and command B via interface Y (for example LAN). In that case it is required to first wait for the response of command A via interface X (RS-422), before sending command B via interface Y (LAN).

*Not obeying this procedure can cause communication failures, so it is recommended to only use one interface at the same time.*



### 3. MODES OF OPERATION

The controller can be used in different *operation modes*. Specific commands or parameters combinations will define the mode of operation the controller is in. For more detailed information, please read the Application Note “*CPSC1 – Modes Of Operation*” (APN01) [REF02].

#### 3.1 Basedrive

Set-and-forget type of positioning. Can be used open-loop or closed-loop (using a setpoint controller on host level) using the Optical Encoder Module (OEM2) or Resistive Sensor Module (RSM).

#### 3.2 Servodrive

Easy to use 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.

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

#### 3.3 Flexdrive

Most dynamic operation mode, but requires a customer supplied Data Acquisition System. Requires setting the CADM2 module into *External Input Mode* prior to use.

## 4. COMMANDS

*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 chapter 3. Specific commands or parameters combinations will define the mode of operation the controller is in.*

*Upon power on of the cabinet please wait a few seconds for the controller to boot, before sending any commands to the controller.*

### 4.1 Command structure

The command structure is very simple and straight forward and independent of the interface used. Each command string sent to the controller consists of a `COMMAND` and is often followed by one or more parameters. Commands must be sent as ASCII characters terminated by a carriage return / line feed control character `CR/LF`. (often the enter-key).

```
COMMAND [parameters] {CR/LF}
```

Responses from the controller are in a similar fashion. All responses will be terminated by a carriage return / line feed control character `CR/LF`. The controller will always be a slave to the host; in other words, the controller will only send a response after receiving a command by the host.

```
RESPONSE {CR/LF}
```

```
/VER
v8.0.20220221
/MODLIST
CADM2,-,RSM,OEM2,-,EDM
MOV 1 1 600 100 0 293 CIA2601 1
Actuating stage.
STP 1
Stopping the stage.
```

Figure 1: Example of sending commands and receiving responses

## 4.2 Command overview

A summary of all available commands (`COMMAND`) for all available modules and *modes of operation* is listed below. Note that commands are not case-sensitive but for the readability of this manual, they will be listed in capital letters throughout the document.

Command	Description	Module	Mode of operation	Paragraph
<code>/VER</code>	Get controller firmware version	n/a	n/a	4.4.1
<code>/MODLIST</code>	Get a list of all installed modules			4.4.2
<code>/STAGES</code>	Get a list of supported actuator and stage types			4.4.3
<code>/IPR</code>	Read IP configuration for the LAN interface			4.4.4
<code>/IPS</code>	Set IP configuration for the LAN interface			4.4.5
<code>/GBR</code>	Read Baudrate setting for the USB or RS-422 interface			4.4.6
<code>/SBR</code>	Set Baudrate setting for the USB or RS-422 interface			4.4.7
<code>FIV</code>	Get firmware version information of installed modules	{All}		4.4.8
<code>FU</code>	Update firmware on installed module		4.4.9	
<code>GFS</code>	Get fail-safe state	CADM2	n/a	4.5.1
<code>MOV</code>	Move (open-loop)		Basedrive	4.5.2
<code>STP</code>	Stop			4.5.3
<code>SDC</code>	Scanner Mode		4.5.4	
<code>EXT</code>	External Input mode		Flexdrive	4.5.5
<code>PGV</code>	Get current position	RSM	Basedrive	4.6.1
<code>PGVA</code>	Get current position of all 3 channels			4.6.2
<code>MIS</code>	Set negative end stop			4.6.3
<code>MAS</code>	Set positive end stop			4.6.4
<code>MIR</code>	Read negative end stop			4.6.5
<code>MAR</code>	Read positive end stop			4.6.6
<code>MMR</code>	Reset negative and positive end stop			4.6.7
<code>EXS</code>	Set excitation duty cycle			4.6.8
<code>EXR</code>	Read excitation duty cycle			4.6.9
<code>RSS</code>	Save settings in non-volatile memory			4.6.10
<code>CGV</code>	Get current counter value	OEM2	Basedrive	4.7.1
<code>CGVA</code>	Get current counter value of all channels			4.7.2
<code>CSZ</code>	Reset current counter value to zero			4.7.3
<code>DGV</code>	Get current raw encoder signal value			4.7.4
<code>OEMC</code>	Automatic Optical Encoder Module calibration			4.7.5
<code>MLS</code>	Get calibration values			4.7.6
<code>DSG</code>	Set detector gain			4.7.7
<code>DSH</code>	Set upper threshold value			4.7.8
<code>DSL</code>	Set lower threshold value			4.7.9
<code>MSS</code>	Store calibration values to nonvolatile memory			4.7.10
<code>EGC</code>	Get current state of all interrupter channels	EDM	Basedrive	4.8.1
<code>EGCL</code>	Get latched state of all interrupter channels			4.8.2
<code>EGV</code>	Get current signal strength of a single interrupter channel			4.8.3
<code>EGVA</code>	Get current signal strength of all interrupter channels			4.8.4
<code>EGE</code>	Get current state of all external digital inputs			4.8.5
<code>EGVE</code>	Get current signal value of all external analog inputs			4.8.6

<b>MLC</b>	Get gain and threshold values of a single interrupter channel			4.8.7
<b>MLG</b>	Get power setting and active state of all interrupter channels			4.8.8
<b>EIN</b>	Set active state of all interrupter channels			4.8.9
<b>SID</b>	Set signal power of all interrupter channels			4.8.10
<b>SIG</b>	Set gain of a single interrupter channel			4.8.11
<b>SHT</b>	Set upper threshold of a single interrupter channel			4.8.12
<b>SLT</b>	Set lower threshold of a single interrupter channel			4.8.13
<b>LDI</b>	Set signal power of all interrupter channels OFF			4.8.14
<b>LMI</b>	Set signal power of all interrupter channel to MIN			4.8.15
<b>LMA</b>	Set signal power of all interrupter channels to MAX			4.8.16
<b>MSF</b>	Store all settings to nonvolatile memory			4.8.17
<b>FBEN</b>	Enable Servodrive	{All}	Servodrive	4.9.2
<b>FBXT</b>	Disable Servodrive			4.9.3
<b>FBCS</b>	Go to setpoint (closed-loop)			4.9.4
<b>FBES</b>	Emergency Stop			4.9.5
<b>FBST</b>	Get status position control			4.9.6

### 4.3 Common parameter arguments

Most commands require additional [parameters] in a particular order. Depending on the [COMMAND] one or 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.  <i>Address 1 = Slot 1 = the module on the leftmost position as seen from front of the cabinet.</i>
[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 <sup>3</sup> .

<sup>3</sup> Consult the Interface Drawing of the particular positioner, actuator or system for the definition of positive- and negative movement.

Parameter	Value	Description
[FREQ] or [FREQx]	1 to 600	Step frequency input. Value is in Hertz [Hz] (numerical values only).  <i>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 might 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.</i>
[RSS]	1 to 100	(Relative) actuator step size parameter input. Value is a percentage [%] (numerical values only) <sup>4</sup> .
[STAGE]	{various}	Sets specific internal drive parameters for the type of positioner, 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 commands

### 4.4.1 /VER – Get controller firmware version

<b>Command</b>	/VER
<b>Response</b> (example)	v8.0.20220221

### 4.4.2 /MODLIST – Get a list of all installed modules

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

<b>Command</b>	/MODLIST
<b>Response</b> (example)	CADM2, CADM2, RSM, OEM2, -, EDM

### 4.4.3 /STAGES – Get a 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.

<sup>4</sup> See product brochures for typical step size values for each actuator or system. Typically leave this at 100[%] unless small(er) steps are required.

<b>Command</b>	/STAGES
<b>Response</b> (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

#### 4.4.4 /IPR – Read IP configuration for the LAN interface

This command will return (a command separated) list of IP settings stored in the controller. Useful to determine the controller’s network settings prior to connecting the controller to a LAN. [MODE] can be either DHCP or STATIC.

<b>Command</b>	/IPR
<b>Response</b>	[MODE], [IP address], [Subnet Mask], [Gateway], [MAC Address]
<b>Response</b> (example)	DHCP, 192.168.15.62, 255.255.255.0, 192.168.15.125, 40:2e:71:90:e4:8a

#### 4.4.5 /IPS – Set IP configuration for the LAN interface

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

<b>Command</b>	/IPS [MODE] [IP address] [Subnet Mask] [Gateway]
<b>Command</b> (example)	DHCP (IP, Subnet Mask and Gateway can be left zero): /IPS DHCP 0.0.0.0 0.0.0.0 0.0.0.0  STATIC IP: /IPS STATIC 192.168.15.62 255.255.255.0 192.168.15.125
<b>Response</b> (example)	Restarting ...

*Note that after changing these settings, the controller will restart automatically and any previously established connection via LAN will be lost (due to changing the IP settings).*

#### 4.4.6 /GBR – Read Baudrate setting for the USB or RS-422 interface

This command will return the Baudrate setting for either the USB (Virtual COM port) or the RS-422 interface. [INTERFACE] must be either USB or RS422.

<b>Command</b>	/GBR [INTERFACE]
<b>Response</b> (example)	115200

#### 4.4.7 /SBR – Set Baudrate setting for the USB or RS-422 interface

Command to set the Baudrate for either the USB (Virtual COM port) or the RS-422 interface. [INTERFACE] must be either USB or RS422. [BAUDRATE] can be set to a value from 9600 to 1000000 (1MBaud). The factory default setting is 115200.

<b>Command</b>	/SBR [INTERFACE] [BAUDRATE]
<b>Command</b> (example)	/SBR USB 115200
<b>Response</b> (example)	Restarting ...

*Note that after changing these settings, the controller will restart automatically and any previously established connection via USB or RS-422 will be lost (due to changing the Baudrate settings).*

#### 4.4.8 FIV – Get firmware version information of installed modules

This command will return the firmware version of the installed module on [ADDR]. [ADDR] can be set from 1 to 6, where 1 – 6 corresponds to Slot1 – Slot6.

<b>Command</b>	FIV [ADDR]
<b>Command</b> (example)	FIV 1
<b>Response</b> (example)	CADM2.7.3.20210802

#### 4.4.9 FU – Update firmware on installed module

Command to update module firmware<sup>5</sup>. [ADDR] needs to be set from 1 to 6, where 1 – 6 corresponds to Slot1 – Slot6. [FILENAME] is the filename of the module firmware binary (.bin file) and needs to be uploaded via the controller’s web interface prior to executing this command. See Appendix A for more information about the web interface.

<b>Command</b>	FU [ADDR] [FILENAME]
<b>Command</b> (example)	FU 1 Cadm2Firmware.bin
<b>Response</b> (example)	Firmware update complete.

*Updating the firmware is typically done only on request by JPE (for example if a new type of positioner has been ordered, but the corresponding drive profile is not yet present in the firmware of the controller).*

*Additionally, it is important that the binary file name matches with the module name that is to be updated. If the firmware file do not match with the module, the module will be bricked (and needs to be returned to JPE for re-programming).*

*Use the FIV command to verify the (currently) installed version number of each installed module.*

<sup>5</sup> Firmware files can be downloaded from the JPE website.

## 4.5 CADM2 specific commands

### 4.5.1 GFS – Get fail-safe state

Get 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 fail-safe state responses.

<b>Command</b>	GFS [ADDR]
<b>Command</b> (example)	GFS 1
<b>Response</b> (example)	NO ERRORS PRESENT

### 4.5.2 MOV – Move (open-loop)

*Note: command specific for Basedrive mode of operation.*

The move command starts moving an actuator or positioner with specified parameters. If an RSM or OEM2 is installed, the position will be tracked automatically if the actuator or positioner 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<sup>6</sup>.

<b>Command</b>	MOV [ADDR] [DIR] [FREQ] [RSS] [STEPS] [TEMP] [STAGE] [DF]
<b>Command</b> (example)	MOV 1 1 600 100 0 293 CLA2601 1
<b>Response</b> (example)	Actuating the stage.

*Please note the following:*

- *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).*

### 4.5.3 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).

<b>Command</b>	STP [ADDR]
<b>Command</b> (example)	STP 1
<b>Response</b> (example)	Stopping the stage.

<sup>6</sup> Note the following driver output (CADM2) / sensor input (RSM or OEM2) pairs: Sensor input channel A is paired with the driver module in Slot 1, input channel B to Slot 2 and input channel C to Slot3. If there is a driver/sensor pair in Slot 5 and 6, sensor input channel A is paired to the driver module in Slot 5.



#### 4.5.4 SDC – Scanner 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).

<b>Command</b>	SDC [ADDR] [VALUE]
<b>Command</b> (example)	SDC 1 512
<b>Response</b> (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).*

#### 4.5.5 EXT – External Input mode

*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.

<b>Command</b>	EXT [ADDR] [DIR] [FREQ] [RSS] [TEMP] [STAGE] [DF]
<b>Command</b> (example)	EXT 1 1 600 100 293 CLA2601 1
<b>Response</b> (example)	External mode enabled.

*Please note that the relative actuator step size (RSS parameter) 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.*

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

<b>Command</b>	PGV [ADDR] [CH] [STAGE]
<b>Command</b> (example)	PGV 2 1 CBS10-RLS
<b>Response</b> (example)	-0.003289070

### 4.6.2 PGVA – Get current position of all 3 channels

*Note: command specific for Basedrive mode of operation.*

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

<b>Command</b>	PGVA [ADDR] [STAGE] [STAGE] [STAGE]
<b>Command</b> (example)	PGVA 2 CBS10-RLS CBS10-RLS CBS10-RLS
<b>Response</b>	[CH1], [CH2], [CH3]
<b>Response</b> (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.

<b>Command</b>	MIS [ADDR] [CH]
<b>Command</b> (example)	MIS 2 1
<b>Response</b> (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.

<b>Command</b>	MAS [ADDR] [CH]
<b>Command</b> (example)	MAS 2 1
<b>Response</b> (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].

<b>Command</b>	MIR [ADDR] [CH] [STAGE]
<b>Command</b> (example)	MIR 2 1 CBS10-RLS
<b>Response</b> (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].

<b>Command</b>	MAR [ADDR] [CH] [STAGE]
<b>Command</b> (example)	MAR 2 1 CBS10-RLS
<b>Response</b> (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).

<b>Command</b>	MMR [ADDR] [CH]
<b>Command</b> (example)	MMR 2 1
<b>Response</b> (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).

<b>Command</b>	EXS [ADDR] [DUTY]
<b>Command</b> (example)	EXS 2 100
<b>Response</b> (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.

<b>Command</b>	EXR [ADDR]
<b>Command</b> (example)	EXR 2
<b>Response</b> (example)	100

#### 4.6.10 RSS – Save settings in 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).

<b>Command</b>	RSS [ADDR]
<b>Command</b> (example)	RSS 2
<b>Response</b> (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 positioner or 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 positioner or 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 4.5.2). 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). It is recommended to use a low(er) step frequency setting (~100Hz).
- 3 Make sure the positioner or 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 positioner or 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 4.5.2), see step #2.
- 5 Make sure the positioner or 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.*

Get the current counter value of a Cryo Optical Encoder (COE) connected to a specific channel [CH] of the OEM2 module. Return value is in [counter ticks]<sup>7</sup>.

<b>Command</b>	CGV [ADDR] [CH]
<b>Command</b> (example)	CGV 4 1
<b>Response</b> (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).*

<sup>7</sup> 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).

#### 4.7.2 CGVA – Get current counter value of all channels

*Note: command specific for Basedrive mode of operation.*

Get the current counter values of all three channels of the OEM2 simultaneously. Return value is in [counter ticks]<sup>7</sup>.

<b>Command</b>	CGVA [ADDR]
<b>Command</b> (example)	CGVA 4
<b>Response</b>	[CH1], [CH2], [CH3]
<b>Response</b> (example)	42,23,16

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

#### 4.7.3 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.

<b>Command</b>	CSZ [ADDR] [CH]
<b>Command</b> (example)	CSZ 4 1
<b>Response</b> (example)	Position counter set to 0.

#### 4.7.4 DGV – Get current raw encoder signal value

*Note: command specific for Basedrive mode of operation.*

Get 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].

<b>Command</b>	DGV [ADDR] [CH]
<b>Command</b> (example)	DGV 4 1
<b>Response</b> (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 positioner or 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) 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.*

#### 4.7.5 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 4.7.6) 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.

<b>Command</b>	OEMC [ADDR] [CH] [CADM2_ADDR] [TEMP] [STAGE]
<b>Command</b> (example)	OEMC 4 1 1 293 CLA2201-COE
<b>Response</b> (example)	Channel calibrated.

#### 4.7.6 MLS – Get calibration values

Note: command specific for Basedrive mode of operation.

Get 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].

<b>Command</b>	MLS [ADDR] [CH]
<b>Command</b> (example)	MLS 4 1
<b>Response</b>	[GAIN], [UT], [LT]
<b>Response</b> (example)	5,164,82

#### 4.7.7 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 4.7.10).

<b>Command</b>	DSG [ADDR] [CH] [GAIN]
<b>Command</b> (example)	DGV 4 1 10
<b>Response</b> (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 4.7.4)*

#### 4.7.8 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 4.7.9). Make sure to run the MSS command to store settings in the controller memory (see paragraph 4.7.10).

<b>Command</b>	DSH [ADDR] [CH] [UT]
<b>Command</b> (example)	DSH 4 1 180
<b>Response</b> (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 most products. Another rule of thumb is to set [UT] to a value of around [DGV(max)] - 60. See also DGV command (paragraph 4.7.4)*

#### 4.7.9 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 4.7.8). Make sure to run the MSS command to store settings in the controller memory (see paragraph 4.7.10).

<b>Command</b>	DSL [ADDR] [CH] [UT]
<b>Command</b> (example)	DSL 4 1 60
<b>Response</b> (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 most products. Another rule of thumb is to set [LT] to a value of around [DGV(min)] + 60. See also DGV command (paragraph 4.7.4)*

#### 4.7.10 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.

<b>Command</b>	MSS [ADDR]
<b>Command</b> (example)	MSS 4
<b>Response</b> (example)	Detector settings stored in flash.



## 4.8 EDM specific commands

### 4.8.1 EGC – Get current state of all interrupter channels

*Note: command specific for Basedrive mode of operation.*

Get 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).

<b>Command</b>	EGC [ADDR]
<b>Command</b> (example)	EGC 2
<b>Response</b>	[CH1], [CH2], [CH3], [CH4], [CH5], [CH6]
<b>Response</b> (example)	0, 0, 1, 1, 0, 1

### 4.8.2 EGCL – Get latched state of all interrupter channels

*Note: command specific for Basedrive mode of operation.*

Get 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.*

<b>Command</b>	EGCL [ADDR]
<b>Command</b> (example)	EGCL 2
<b>Response</b>	[CH1], [CH2], [CH3], [CH4], [CH5], [CH6]
<b>Response</b> (example)	1, 1, 0, 0, 1, 0

### 4.8.3 EGV – Get current signal strength of a single interrupter channel

*Note: command specific for Basedrive mode of operation.*

Get 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).

<b>Command</b>	EGV [ADDR] [CH]
<b>Command</b> (example)	EGV 2 4
<b>Response</b> (example)	4815

### 4.8.4 EGVA – Get current signal strength of all interrupter channels

*Note: command specific for Basedrive mode of operation.*

Get 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).

<b>Command</b>	EGVA [ADDR]
<b>Command</b> (example)	EGVA 2
<b>Response</b>	[CH1], [CH2], [CH3], [CH4], [CH5], [CH6]
<b>Response</b> (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.

<b>Command</b>	EGE [ADDR]
<b>Command</b> (example)	EGE 2
<b>Response</b>	[DI1], [DI2], [DI3], [DI4], [DI5], [DI6]
<b>Response</b> (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).

<b>Command</b>	EGVE [ADDR]
<b>Command</b> (example)	EGVE 2
<b>Response</b>	[AI1], [AI2], [AI3]
<b>Response</b> (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.

<b>Command</b>	MLC [ADDR] [CH]
<b>Command</b> (example)	MLC 2 1
<b>Response</b>	[GAIN], [UT], [LT]
<b>Response</b> (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.

<b>Command</b>	MLG [ADDR]
<b>Command</b> (example)	MLG 2
<b>Response</b>	[DUTY CYCLE], [ACTIVE STATE]
<b>Response</b> (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).

<b>Command</b>	EIN [ADDR] [STATE]
<b>Command</b> (example)	EIN 2 1
<b>Response</b> (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 ‰.

<b>Command</b>	SID [ADDR] [DUTY CYCLE]
<b>Command</b> (example)	SID 500
<b>Response</b> (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).

<b>Command</b>	SIG [ADDR] [CH] [GAIN]
<b>Command</b> (example)	SIG 2 1 255
<b>Response</b> (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).

<b>Command</b>	SHT [ADDR] [CH] [UT]
<b>Command</b> (example)	SHT 2 1 200
<b>Response</b> (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).

<b>Command</b>	SLT [ADDR] [CH] [UT]
<b>Command</b> (example)	SLT 2 1 100
<b>Response</b> (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].

<b>Command</b>	LDI [ADDR]
<b>Command</b> (example)	LDI 2
<b>Response</b> (example)	Endswitch power turned off.

*This is useful for when it is 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.

<b>Command</b>	LMI [ADDR]
<b>Command</b> (example)	LMI 2
<b>Response</b> (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.

<b>Command</b>	LMA [ADDR]
<b>Command</b> (example)	LMA 2
<b>Response</b> (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.

<b>Command</b>	MSF [ADDR]
<b>Command</b> (example)	MSF 2
<b>Response</b> (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 (OEM<sub>2</sub>) or Resistive Sensor Module (RSM) installed and is only available as function of the CLI.

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

After enabling Servodrive, the basic movement sequence<sup>8</sup> 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 (= closer to setpoint), the step frequency will be reduced. Near the setpoint, the positioner will be stepping with a ~1Hz frequency.
- 2 When the positioner crosses the setpoint (overshoot), the controller reverses the direction of movement and continues with a reduced *step size* (50%).
- 3 When the positioner crosses the setpoint again, the control loop will stop and set the status to “Finished”. In practice this means that the positioner will be within one piezo stroke of the setpoint. If required, switch to *Scan* mode (see paragraph 4.5.4) to do fine positioning.
- 4 Should the positioner 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 [FREQ<sub>x</sub>].

<b>Command</b>	FBEN [STAGE1] [FREQ1] [STAGE2] [FREQ2] [STAGE3] [FREQ3] [DF] [TEMP]
<b>Command</b> (example)	FBEN CBS10-RLS 300 CBS10-RLS 300 CBS10-RLS 300 1 293
<b>Response</b> (example)	Control loop enabled.

<sup>8</sup> This control loop profile is chosen for the sole reason that this is most reliable and robust when operating a positioner or actuator in any kind of environment (ambient, vacuum or cryogenic).

#### 4.9.3 FBXT – Disable Servodrive

Disable the internal position feedback control.

<b>Command</b>	FBXT
<b>Response</b> (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)<sup>9</sup>, whereas relative positioning is relative to the current count value.

<b>Command</b>	FBCS [SP1] [ABS] [SP2] [ABS] [SP3] [ABS]
<b>Command</b> (example, SP in [m])	FBCS -1e-3 0 1e-3 1 1.23e-4 1
<b>Command</b> (example, SP in [rad])	FBCS 6.28 0 0 0 0 0
<b>Response</b> (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).*
- *When active, the (blue) Output Active LED on the CADM2 will be ON continuously.*

#### 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.

<b>Command</b>	FBES
<b>Response</b> (example)	Control loop emergency stop enabled.

<sup>9</sup> 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)

#### 4.9.6 FBST – Get status position control

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

<b>Command</b>	FBST
<b>Response</b>	[ENABLED] [FINISHED] [INVALID SP1] [INVALID SP2] [INVALID SP3] [POS ERROR1] [POS ERROR2] [POS ERROR3]
<b>Response</b> (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 <sup>10</sup> .
[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.

*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
Unknown command	Check the command. Most likely there is a typo in the string.
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: <code>MOV 1 0 CLA2601</code> , the controller system will respond with this error (because the <code>MOV</code> parameter requires values for <code>FREQ</code> , <code>RSS</code> , <code>TEMP</code> , <code>STEPS</code> and <code>DF</code> as well).
Stage axis is undefined	Check the <code>STAGE</code> parameter. Some stage configurations require to define a specific axis as well. One example is the stage parameter for the <code>CS021-RLS</code> : in this case, the <code>STAGE</code> parameter needs to be <code>CS021-RLS.X</code> , <code>CS021-RLS.Y</code> or <code>CS021-RLS.Z</code>

<sup>10</sup> 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.



	depending on the axis that is connected to a specific CADMz output.
Invalid stage name	Check the STAGE parameter. Most likely there is a typo.

#### 4.11 Fail-safe State

When using the Fail-safe state command (GFS, see paragraph 4.5.1), the controller will display a Fail-safe State value. In normal operation this value should be 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. TIPS & TRICKS, KNOWN ISSUES

### 5.1 Return values

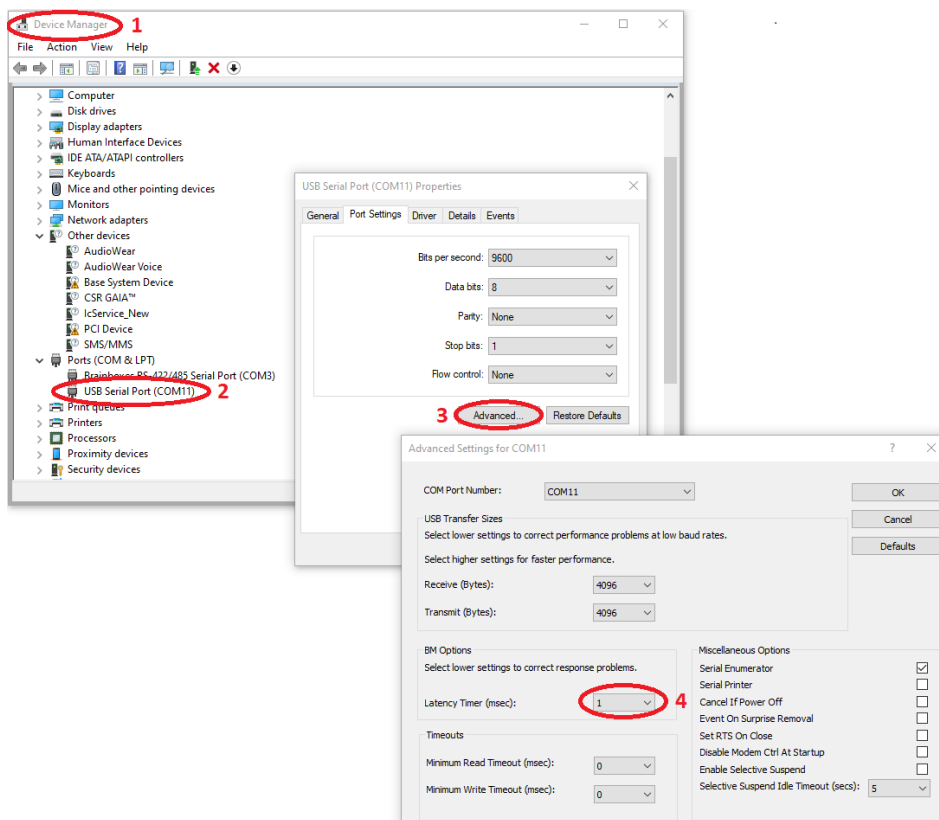
Some commands may not return comma separated values when they should according to this user manual. Instead, these commands will return values separated by a *carriage return* (CR) control character. This is a known issue and will be resolved in the next firmware update.

### 5.2 Improve USB Virtual COM port communication speed

By default the (FTDI) virtual com port driver is initialized with suboptimal settings. This results in a limited communication speed. For normal, low speed manual operation this is not an issue, but when automating the control via higher-level control software it can be beneficial to change some settings to boost the communication speed.

As example using Windows 10 OS:

- 1 Open the Windows *Device Manager*
- 2 Under "Ports(COM & LPT)" search for the connected "USB Serial Port" that is the CPSC1 and right click to open its Properties.
- 3 Under "Port Settings" click "Advanced...".
- 4 Under "BM Options" set the "Latency Timer (msec):" to 1.



An equal setting can be changed as well on other operating systems that support the (FTDI) virtual com port driver.

## APPENDIX A CONTROLLER WEB INTERFACE

The controller has a very basic web interface which currently is only used for uploading module firmware (.bin) files and / or uploading or installing controller firmware (.cpsc files).

Open a browser window and navigate to the following address to open the web interface:

```
http://[IP Address]:4000
```

If DHCP is enabled, [IP Address] is set by a DHCP server active on the local area network (LAN), otherwise enter the manually set IP address (use the /IPR command to see what the current IP address is). If only one controller is connected to the LAN, it is also possible to use the default hostname "cpsc1":

```
http://cpsc1:4000
```

In either case, the port number is always 4000.



Figure 3: CPSC1 Web Interface

**To upload firmware files:** click the `Choose File` button to select .bin and/or a .cpsc file and click the `Submit` button to upload the file to the controller.

Once files have been uploaded, they will be displayed in the `CPSC1 (*.cpsc)` and `Modules (*.bin)` section. Each uploaded file will have an accompanying delete-link to remove the file from the controller if necessary.

*It is also possible to upload non-firmware files (for example the PDF of this Software User Manual), these will then be listed under "Other files". Note that the CPSC1 is not a mass storage device, so file sizes, file types and available storage is limited.*

CPSC1 (*.cpsc)					
<a href="#">update</a>	<a href="#">Pci3V8.0.20220221.cpsc</a>	2022-03-17 13:34:19	913888 bytes	MD5: 9936090f98a09102951375c8f353931e	<a href="#">delete</a>
Modules (*.bin)					
	<a href="#">Cadm2Firmware.bin</a>	2022-03-17 13:33:52	30004 bytes	MD5: 03eeba714d6e5cf155d82d72f1e069a2	<a href="#">delete</a>
	<a href="#">EdmFirmware.bin</a>	2022-03-17 13:33:57	13012 bytes	MD5: 4a119e6e43133a8141b160966e6eb2c1	<a href="#">delete</a>
	<a href="#">RsmFirmware.bin</a>	2022-03-17 13:34:13	18504 bytes	MD5: 3971411b60fd70100b45ccc65d993179	<a href="#">delete</a>
	<a href="#">Dem2Firmware.bin</a>	2022-03-17 13:34:02	17468 bytes	MD5: 8524a7910ac8185a1c46e842fa4f9b82	<a href="#">delete</a>
Other files					

Figure 4: Uploaded firmware files

To install firmware files: module firmware (.bin) must be installed by using the `FU` command, see section 4.4.9. Controller firmware (.cpsc) can only be installed via the update link on the left in the web interface.

*Please note that when updating the controller firmware, the web server will go offline for a short while as well (since the controller will be rebooted) and any IP settings will revert to factory default settings. Updating the controller firmware should take only a few minutes to complete.*