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XLA-INTG
XUMU-INTG
Controller manual – 1.3

The integrated controller for our XLA linear actuators and XUMU motor units provides advanced motion control possibilities in a very compact package. It enables the advantages of our actuators and motors such as high-speed and accurate positioning without the need for an external controller. Interfacing of power and communication is combined in one ZIF-connector, with the option of daisy chaining between devices.

Communication via the industry-standard CANopen protocol guarantees robust and predictable real-time behaviour. Other communication protocols such as USB, UART, RS232… are supported through an adapter module. Basic motion tasks can also be controlled via I/O signals.

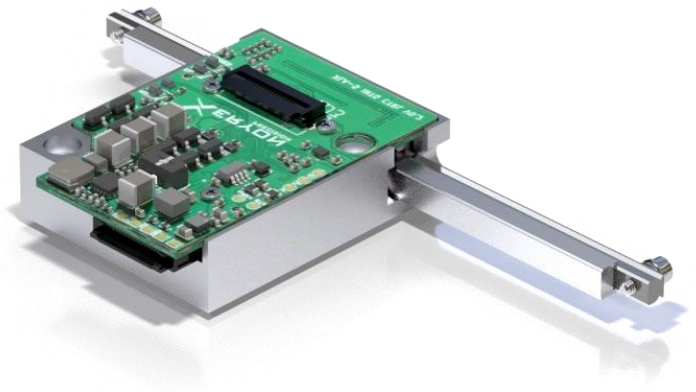

Figure 1: XLA-5-INTG

Image for illustration only. May not be an exact representation of the product

CONTENT

1. KEY SPECIFICATIONS

Compatible products	XLA-5-INTG XUMU-5-INTG XLA-10-INTG (to be released soon) XUMU-10-INTG (to be released soon)
Number of axes	Single-axis (CAN or I/O control) Up to 4 axes daisy-chainable (CAN control)
Power supply	12-48 VDC, 10 W (XLA-5-INTG) 24-48 VDC, 20 W (XLA-10-INTG)
Temperature range	-30°C to +70°C
Connector to device	2x ZIF (16 core, 0.5 mm pitch, with retention ears)
Control types	Open and closed loop control
Key communication options	CANopen (CiA 402 / DS402 profile) USB, UART, RS232… (with CAN adapter module) I/O control
Software support	Windows GUI (to be released soon), Python
Motion profile	Point-to-point with jerk-limited profile Arbitrary trajectory
Encoder	Optical, incremental (integrated)
Supported resolutions[1] Rounded (effective)	10 µm (9407.4 nm) 1 µm (1007.9 nm) 250 nm (249.8 nm) 100 nm (100.8 nm)
Response time **(from command to motion start)**	1-2 ms (CAN) 1 ms (I/O control in closed-loop) <1 ms (I/O control in open-loop)
Error detection	Overcurrent, thermal, short-circuit…

[1] The listed resolutions are rounded values used for naming purposes. For calculations and unit conversions, use the effective resolution values. For more information, refer to Encoder Resolution.

2. GLOSSARY

AI	Analog Input
ADC	Analogue-to-Digital Converter
AMR	Absolute Maximum Rating
CAN	Controller Area Network bus, a robust and efficient fieldbus originally developed for automotive applications
CANopen	High-level communication protocol and device profile specification designed for embedded control systems, particularly in automation and motion control applications
CMOS/TTL	CMOS voltage range is 0-3.3 V, TTL voltage range is 0-5 V
DI	Digital Input
DO	Digital Ouput
ESD	Electro-Static Discharge
EDS	Electronic Data Sheet. An EDS file describes the structure and contents of a device's Object Dictionary (OD) in a standardized format, enabling tools and configuration software to interpret and interact with the device
GND	Ground
GPIO	General purpose input/output
I/O	Input and Output
FFC	Flat Flexible Cable type used for connection the integrated controller PCB to the host/master or for daisy-chaining of multiple devices
FPC	Flexible Printed Circuit that can be used as an alternative to an FFC
OD	Every device contains an Object Dictionary (OD), a structured list of entries that represent parameters, configuration data, and status values. These can be accessed or modified via SDOs
PDO	Process Data Object. PDOs are used for real-time data transfer. They follow a producer/ consumer model and carry up to 8 bytes. Transmission can be event-driven, synchronous or cyclic
PWM	Pulse Width Modulation
SDO	Service Data Object. SDOs are used for non-time-critical communication. They follow a client/server model and allow reading or writing any Object Dictionary entry
STO	Safe Torque Off
VIN	Supply voltage to the integrated controller.
XLA	Xeryon Linear Actuator
XUMU	Xeryon Motor Unit
ZIF	Zero Insertion Force connector type used on the integrated controller PCB

3. ELECTRICAL CONNECTION

3.1. Overview

Figure 1 shows an overview of the electrical connections on an integrated controller (XLA-5-INTG). Pin layout direction is indicated for both ZIF16 connectors.

In the following subsections the different electrical connections are described in detail.

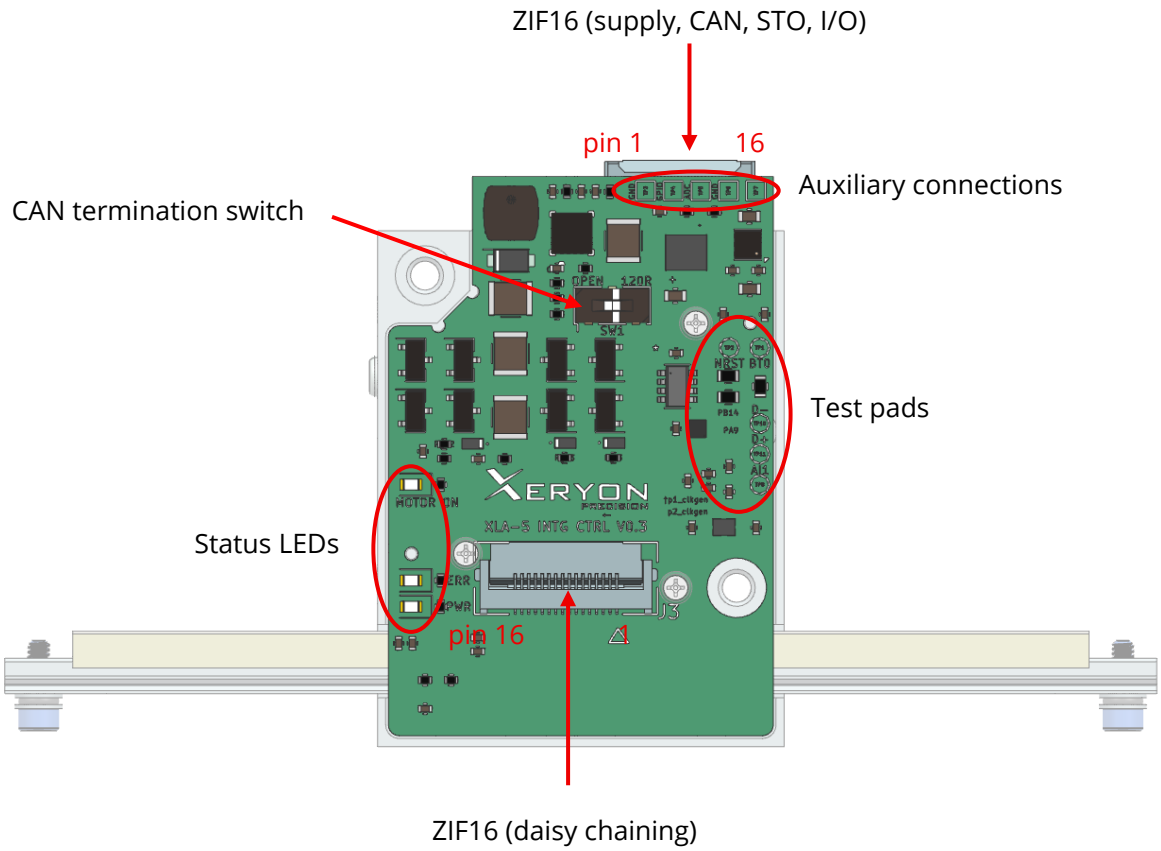

Figure 2: Overview of the electrical connections on an XLA-5-INTG controller

3.2. ZIF16 - Connector type and pin layout

Connector information

- Type: Molex 505110-1692
- Contact orientation: bottom contact (i.e. FFC contacts towards PCB)
- Pin layout direction: see Figure 1
- Recommended FFC: Molex 15018-0181 (305 mm, other lengths available)

ZIF16 (supply, CAN, STO, I/O)

Pin	Function	Voltage range	Protected
1	GND	-	ESD
2	VIN	12-55 V	up to 60 V
3	VIN	12-55 V	up to 60 V
4	STO1	< 2.0 V (low) > 2.0 V (high)	yes, up to 60 V
5	CANL	3.3/5 V	yes, by transceiver
6	CANH	3.3/5 V	yes, by transceiver
7	AI1/PWM	*	ESD
8	DI1	*	ESD
9	DI2	*	ESD
10	DI3	*	ESD
11	DI4	*	ESD
12	DO1	*	ESD
13	DO2	*	ESD
14	DO3	*	ESD
15	DO4	*	ESD
16	GND	-	ESD

** All IOs are CMOS- and TTL-compliant and up to 5 V tolerant, unless specified otherwise*

[1] Safe Torque Off function, pin needs to be pulled high in order to enable motion

ZIF16 (daisy chaining)

Pin	Function	Voltage range	Protected
1	GND	-	ESD
2	reserved	-	-
3	reserved	-	-
4	reserved	-	-
5	reserved	-	-
6	reserved for PWM4	*	ESD
7	reserved for PWM3	*	ESD
8	reserved for PWM2	*	ESD
9	reserved for PWM1	*	ESD
10	reserved	-	-
11	CANH	3.3/5 V	yes, by transceiver
12	CANL	3.3/5 V	yes, by transceiver
13	STO1	<2.0 V (low) >2.0 V (high)	yes, up to 60 V
14	VIN	12-55 V	up to 60 V
15	VIN	12-55 V	up to 60 V
16	GND	-	ESD

** All IOs are CMOS- and TTL-compliant and up to 5 V tolerant, unless specified otherwise*
[1] Safe Torque Off function, pin needs to be pulled high in order to enable motion

FFC contact orientation

The contact orientation of the FFC with respect to the ZIF16 connector needs to be observed. Both ZIF16 connectors have bottom-side contacts, meaning that the FFC contacts need to be oriented towards the PCB as indicated in Figure 3.

Note: wrong orientation of the FFC will not damage the device. Remove power and correct the FFC orientation.

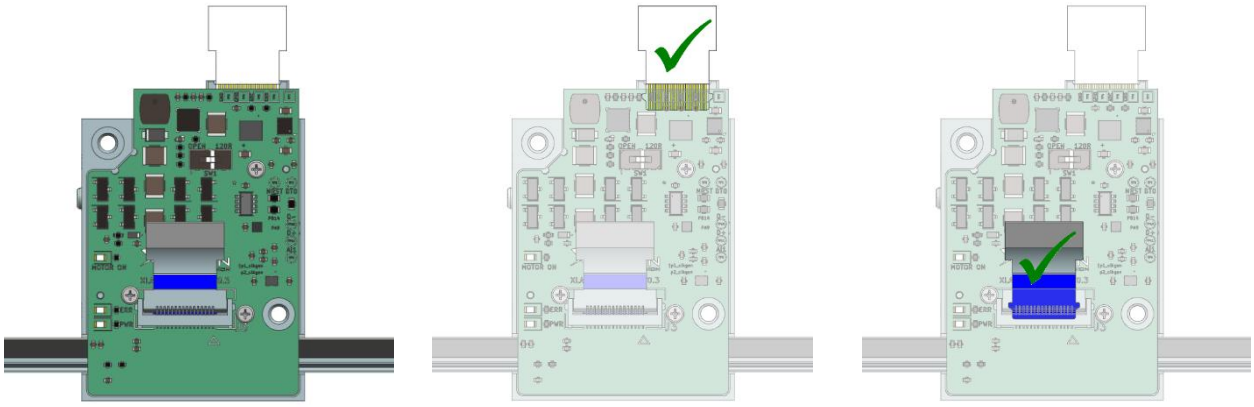

Figure 3: Contact orientation of the FFC in both ZIF16 connectors (for XLA-5-INTG). The contacts of the FFC are always directed towards the controller PCB

Recommended mating FFC types

The integrated controllers are supplied with the following FFC:

- FFC 305 mm, 16 core, 0.5 mm pitch with same side contacts and latching/retention ears
- Molex 15018-0181

When using an alternative FFC type, the conductor width and thickness should result in a conductor cross section of 0.03 mm^2 to enable a current capacity of 0.55 A per conductor.

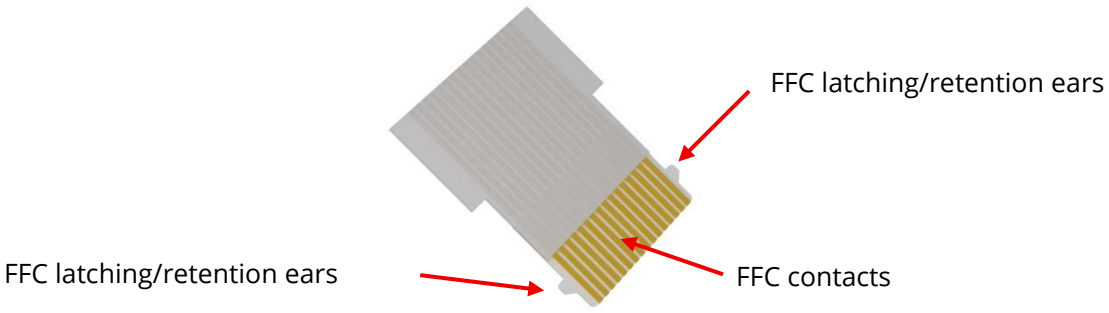

Figure 4: Detail view of the contacts and latching ears of the supplied FFC

3.3. Power supply

The table below shows the power supply requirement depending on the type and number of daisy-chained devices.

Number of devices XLA-5-INTG XUMU-5-INTG	Supply voltage range	Supply power (recommended)
1 (no daisy chaining)	12-55 VDC	10 W
2 daisy-chained	24-55 VDC	20 W
3 daisy-chained	36-55 VDC	30 W
4 daisy-chained	48-55 VDC	40 W

Number of devices XLA-10-INTG XUMU-10-INTG	Supply voltage range	Supply power (recommended)
1 (no daisy chaining)	24-55 VDC	20 W
2 daisy-chained	48-55 VDC	40 W

Notes:

- *Only supply power after connecting the FFCs to the ZIF16 connectors. Connecting or disconnecting of the FFCs when power is supplied, may damage the controller PCB!*
- *Power consumption in standby (motor not activated) should be around 0.9 W (measured on PCB revision V0.3).*
- *Both VIN supply lines and both GND lines of the ZIF16 connector need to be connected.*
- *Connecting of more than 4 controllers is possible:*
  - *When not all daisy-chained devices are operated simultaneously;*
  - *Separate power supply lines are routed to each integrated controller (individual ZIF16 connection).*

3.4. CAN bus termination

CAN bus termination is essential for ensuring reliable communication in a CAN network. It requires two 120 R resistors placed at both ends of the bus to prevent signal reflections and maintain data integrity.

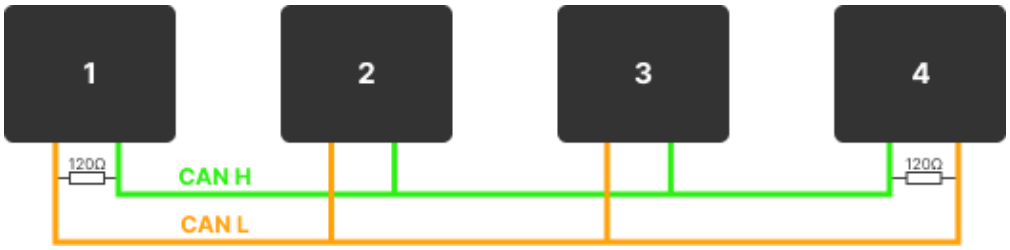

Figure 5: schematic layout of CAN bus termination at both ends of the bus

- Master/host side: on our breakout PCB, CAN bus termination is already provided at the host or master side. When designing a custom PCB for OEM applications, termination needs to be provided by the customer.
- Controller side: on the integrated controller, CAN bus termination can be set with switch SW1. When the slider is set towards 120 R, termination is enabled. No termination is present when set towards OPEN (see Figure 6).
  - 1 device (no daisy-chaining): set SW1 towards 120 R. This is the default setting.
  - 2 to 4 devices daisy-chained: set SW1 towards 120 R on the last controller on the CAN bus. Set SW1 towards OPEN on the other controllers.

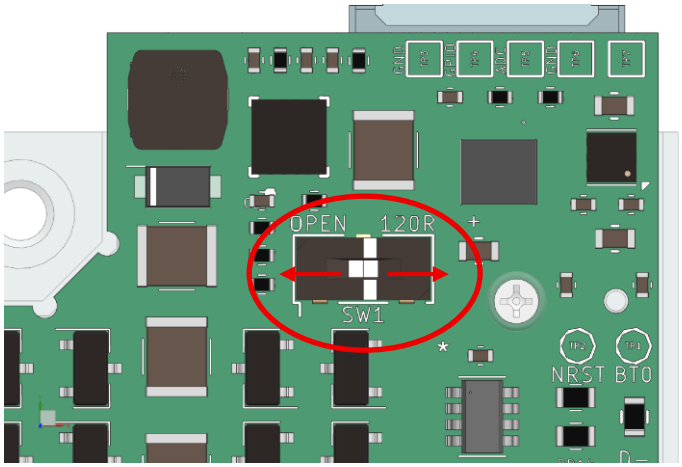

Figure 6: CAN bus termination can be set with switch SW1. When the slider is set towards 120 R, termination is enabled. No termination is present when set towards OPEN

3.5. Status LEDs

The integrated controller has three status LEDs. Figure 7 show the location of the status LEDs on the integrated controller.

For light-sensitive applications, the status LEDs can be switched off selectively via the control software. All LEDs are activated by default.

LED function	LED colour	Can be switched off
power (3.3 V)	green	yes
motor on	orange	yes
error	red	yes

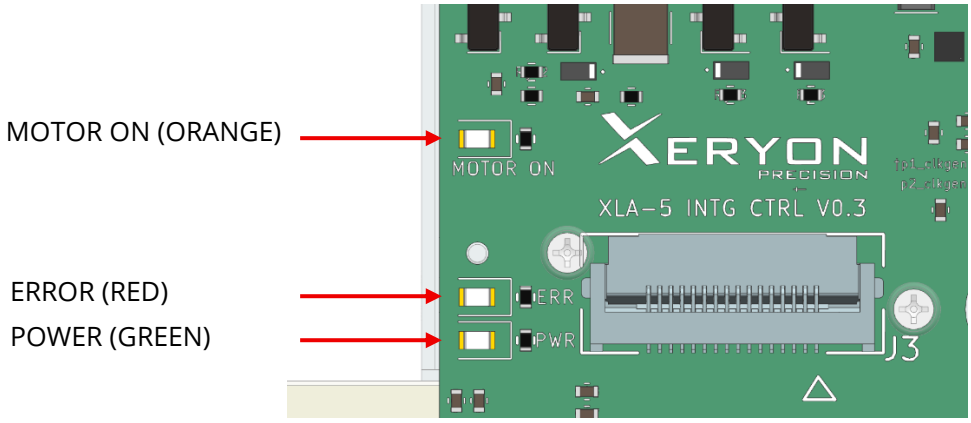

Figure 7: Location of the status LEDs on the integrated controller of an XLA-5-INTG

3.6. Test pads and auxiliary connections

Figure 8 shows the test pads and auxiliary connections on the integrated controller. Their function is described in the below tables.

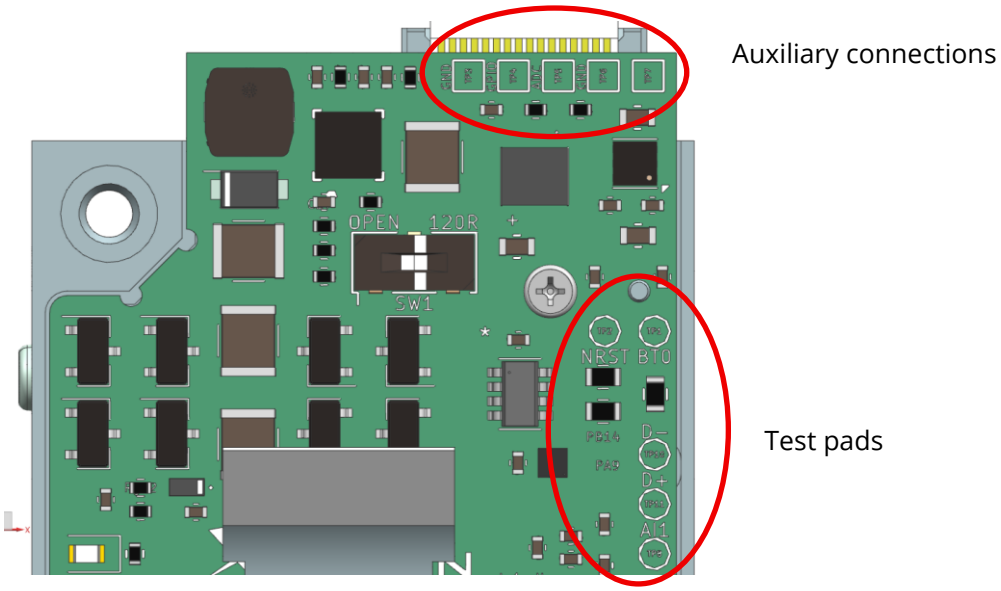

Figure 8: Location of the test pads and auxiliary connections on the integrated controller of an XLA-5-INTG

Test pad	Function	Remark
NRST	microcontroller reset	pull high to perform reset
BTO	microcontroller bootloader mode	pull high to run bootloader
D-	USB data	not used
D+	USB data	not used
AI1	AI1/PWM	also available on ZIF16 (supply, CAN, STO, I/O)

Auxiliary connection	Function	Remark
GND	ground	reserved
GPIO	general purpose I/O	reserved
ADC	analog input	reserved
GND	ground	reserved
unnamed (TP7)	not connected	-

3.7. Connection examples

Figure 9 and Figure 10 provide connection examples for respectively the case of a single device and two devices connected via daisy chaining.

Single device (no daisy chaining) using a breakout PCB and a USB-to-CAN adapter

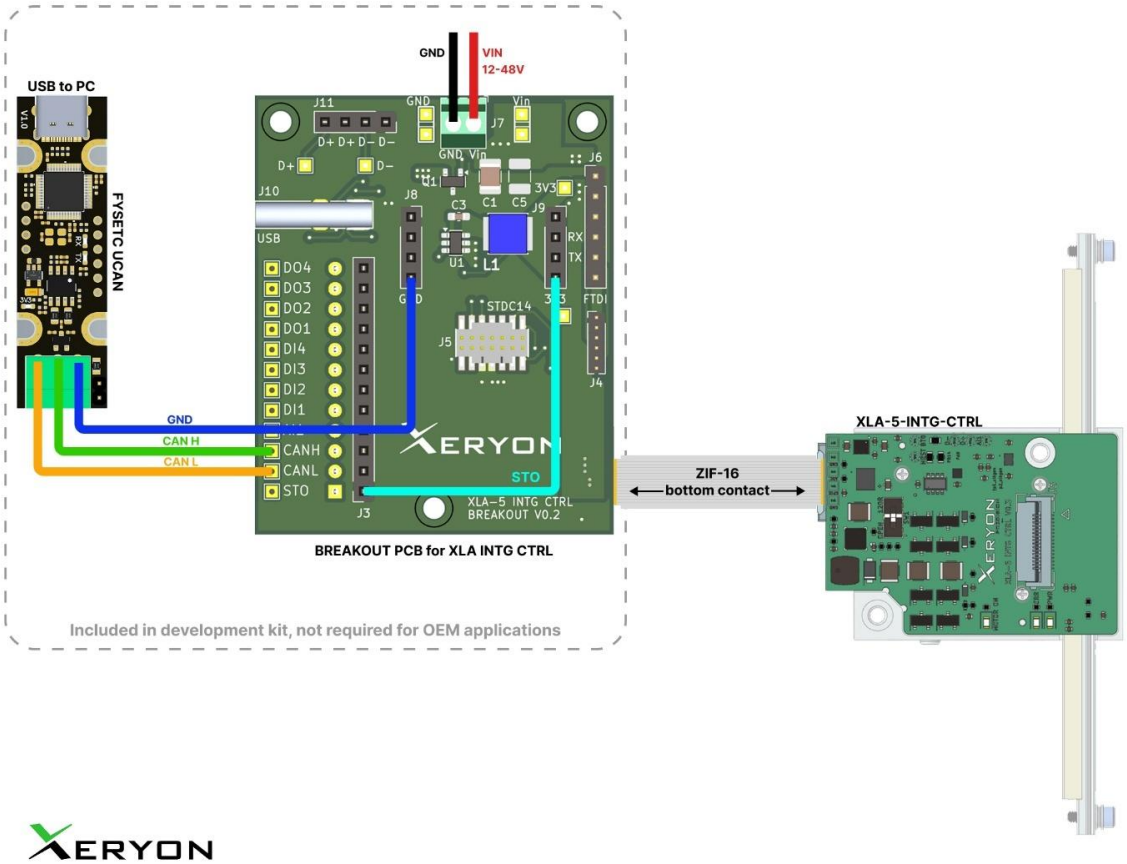

Figure 9: Schematic layout of the electrical connections for controlling a single device

Daisy chaining of two devices

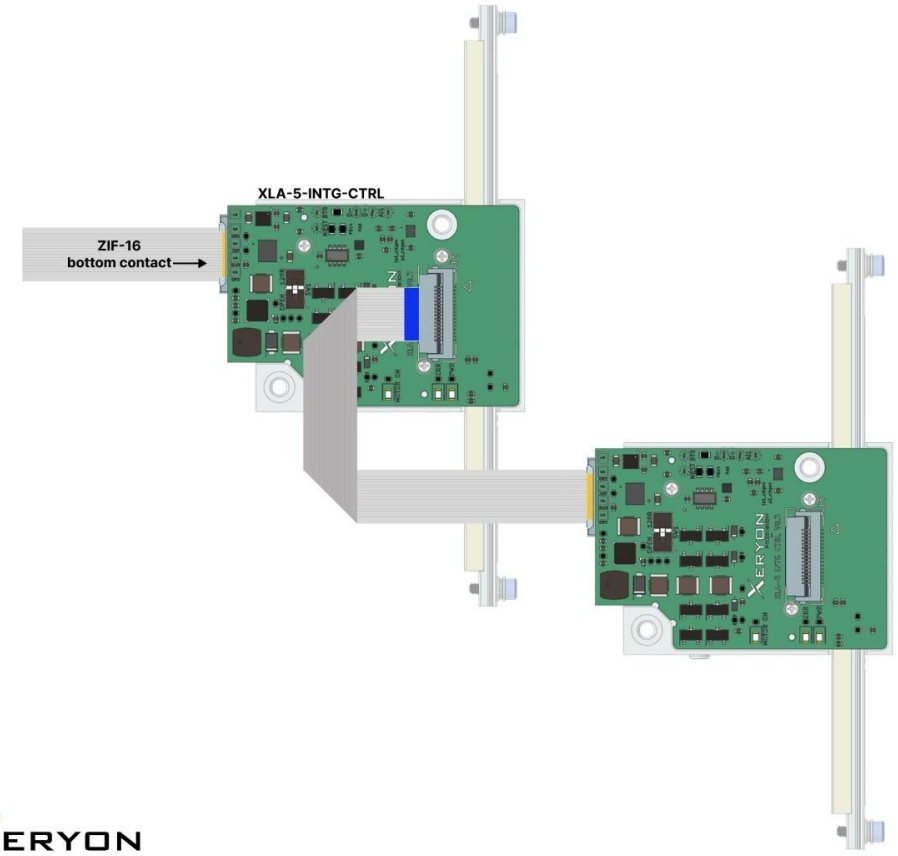

Figure 10: schematic layout of the electrical connections in case of daisy chaining of two devices

4. ENCODER RESOLUTION

Each actuator model is defined by a specific resolution that describes its positioning accuracy. The effective resolution defines the true encoder scaling. The effective resolution must always be used in calculations or when converting between encoder counts and physical units.

Although product names, datasheets and software use rounded resolution values for convenience, the internal encoder operates at an effective resolution that slightly differs from the rounded value. This difference ensures precise motion control and accurate position feedback.

When converting between encoder counts and physical displacement (for example, millimeters), using the rounded resolution will introduce small but cumulative errors in position calculations.
To ensure accurate positioning and measurement, always use the effective resolution value in your computations.

Note: An increment (or count) refers to the smallest measurable step detected by the encoder.

4.1. Conversion Principle

To convert encoder counts to millimeters (or vice versa), apply the following formula using the effective resolution:

$$Displacement\ (mm) = \frac{Encoder\ Counts}{Effective\ increments\ per\ mm}$$

The effective increments per millimeter are defined as:

$$\text{Effective Increments per mm} = \frac{1{,}000{,}000.0}{Effective\ Resolution\ (in\ nm)}$$

5. GETTING STARTED

This section describes how to get started with the development kit of the integrated controller. In a step-by-step plan, the required electrical connections are explained. CANopen communication is easily set up through a series of Python programming examples.

The technical content of this section is located on the following public GitHub repository:

https://github.com/Xeryon-Precision/XLA-INTG_prog_examples

6. CAN CONTROL

CAN communication of the integrated controller is implemented according to the CiA 402 device profile for drives and motion control. This device profile is a CANopen standard for networked automation devices that uses CAN as the lower layer. Background information on CAN bus and CANopen can be found here:

- https://xeryon.com/download-files/Xeryon%20CANopen%20Introduction%20-%20v1.1.pdf

The CiA 402 device profile for drives and motion control is available here:

https://www.can-cia.org/can-knowledge/cia-402-series-canopen-device-profile-for-drives-and-motion-control

6.1. Object Dictionary (OD)

Every device or node in the network contains an Object Dictionary (OD). This is a structured list of entries that represent parameters, configuration data, and status values. These can be accessed or modified via SDO messages.

6.2. Electronic Data Sheet (EDS)

An Electronic Data Sheet (EDS) describes the structure and contents of a device's Object Dictionary (OD) in a standardised format, enabling tools and configuration software to interpret and interact with the device.

The EDS of the integrated controller can be found here:

https://github.com/Xeryon-Precision/XLA-INTG_prog_examples/tree/main/eds

- xeryon_xla_5_eds.eds
- xeryon_xla_5_eds_docu.txt (human-readable version)

6.3. Supported operation modes

Table 1 gives an overview of the supported operation modes of the integrated controller. Each operation mode is described in detail. The fields marked in green are available in the current version of the firmware. Fields marked in red are not yet supported. Please contact us for more information.

	Operation mode				
	Open-loop	**Homing (hm)**	**Profile velocity (pv)**	**Profile position (pp)**	**Trajectory***
Status	in development	supported	in development	supported	possible with set of setpoints method in pp mode
Remark		CiA 402 homing method 33 and 34			firmware on request

Table 1: overview of the supported operation modes of the integrated controller

** Currently not implemented as a separate operation mode*

Open-loop mode

In the open-loop operation mode, the device is controlled by a CAN object that modulates the motor force and speed. There is no encoder-based feedback control. Modulation of the motor power is realised by changing the piezo excitation signal.

Feedback: encoder feedback for limit detection in case of XLA-INTG, no feedback in case of XUMU-INTG

Homing mode (hm)

In order to reference the incremental encoder on the integrated controller, homing must be performed after powering the device. The encoder remains in a referenced state as long as the system is powered.

The homing operation mode supports CiA 402 homing methods 33 and 34 (homing on index pulse). Homing speed, acceleration and home offset are configurable settings.

Feedback: integrated encoder

Profile velocity mode (pv)

In the profile velocity operation mode (pv), the device speed is controlled by a target velocity. The encoder signals are used for velocity feedback control. Profile acceleration and jerk can be defined. Configurable software limits keep the rod position within a predefined range.

Feedback: integrated encoder

Profile position mode (pp)

In the profile position operation mode (pp) , the device position is defined by sending setpoints to the integrated controller. The encoder signals are used for position feedback control. Profile speed, acceleration and jerk can be defined. Configurable software limits keep the rod position within a predefined range.

Feedback: integrated encoder

Motion profile: jerk-limited

Trajectory mode

In trajectory mode, the device can be commanded to follow an arbitrary trajectory. This trajectory consists of a series of setpoints. Linear interpolation is performed in between two successive setpoints. The encoder signals are used for position feedback control. Configurable software limits keep the rod position within a predefined range.

The trajectory mode is currently not implemented as a separate operation mode. It is part of the profile position mode by making use of the set of setpoints method. In this method the host/master continuously sends new setpoints to the integrated controller. One setpoint is buffered in the controller. Correct timing of setpoint communication and processing is guaranteed by a handshaking procedure.

Feedback: integrated encoder

Motion profile: linear interpolation between setpoints

6.4. Supported CAN adapters

The integrated controller only supports CAN for direct communication. By using CAN adapter modules, other protocols can be used to communicate to the integrated controller (see Figure 11).

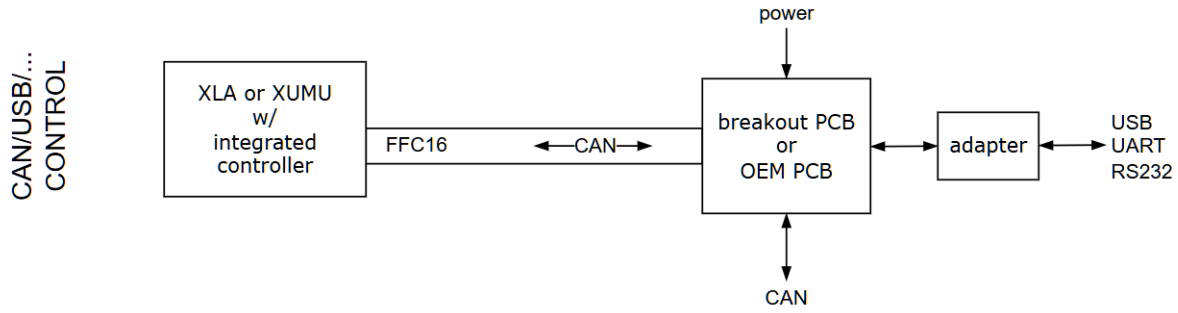

Figure 11: schematic layout of the connections towards the integrated controller using a CAN adapter

USB

USB communication is possible by connecting a CAN-to-USB adapter. Xeryon includes the FYSETC UCAN adapter in its development kits and recommends to use this adapter for prototyping. The schematics and firmware are available in the below-mentioned links. This information can serve as basis for integration of a CAN-to-USB adapter on a customer PCB for OEM applications.

- FYSETC UCAN adapter: https://www.fysetc.com/products/fysetc-ucan-board
- PCB schematics: https://github.com/FYSETC/UCAN/tree/main
- Firmware:
  - https://canable.io/updater/canable1.html (updater tool)
  - https://github.com/normaldotcom/canable-fw (SLCAN)
  - https://github.com/normaldotcom/candleLight_fw (native SocketCAN)

The FYSETC UCAN adapter supports both SLCAN as SocketCAN:

- SLCAN:
  - Supported on Windows and Linux;
  - Required when using the Xeryon firmware update tool.
- SocketCAN: only supported on Linux.

Notes:

- *The CAN-to-USB adapter must use a crystal-based clock. For this reason, all CANable 2.0 based designs should be avoided.*
- *Waveshare CAN-to-USB adapters are not supported in the program examples because they use a proprietary driver set.*

UART

CAN-to-UART adapters are readily available, but currently there is no support from Xeryon for the host/master program code.

RS232

CAN-to-RS232 adapters are readily available, but currently there is no support from Xeryon for the host/master program code.

6.5. Daisy chaining

Multiple devices can be daisy chained on the CAN bus (see Figure 12). This simplifies cabling significantly. Each device is recognised by a unique node ID ranging from 0 to 127. It is important to consider the maximum number of nodes when also sharing power over the FFC cabling (see section 3.3).

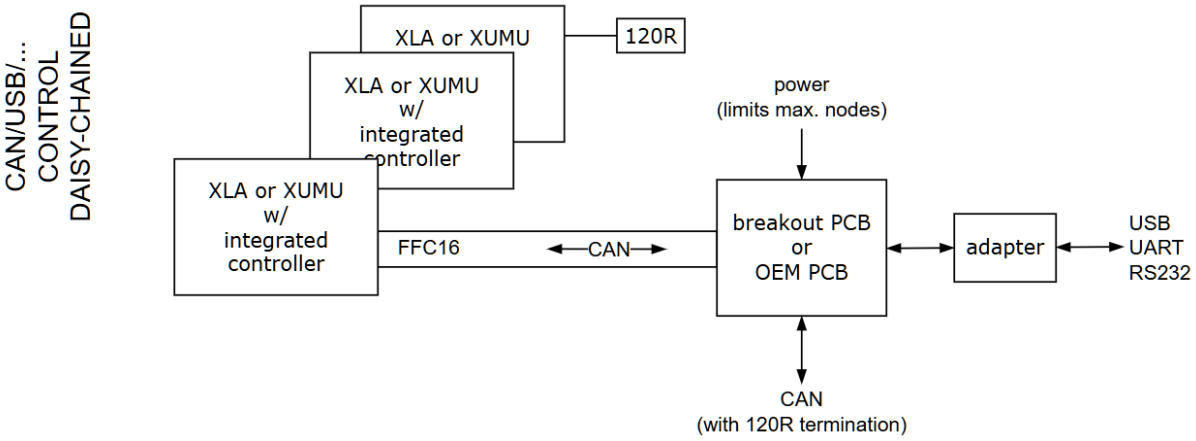

Figure 12: schematic layout in case of daisy chaining of devices

6.6. Firmware update over CAN

The firmware running on the integrated controller can be updated at the customer site. Updating of individually connected or daisy-chained devices is possible using the CAN communication lines. No dedicated programming hardware is required.

Firmware updates are gradually released in order to support additional functionalities or to fix bugs.

Please contact our support team for more information.

7. I/O CONTROL

Communication to the integrated controller is possible by using direct communication (CAN control described in section 6) or through I/O signals. For initialisation purposes, direct communication is required. Hereafter, the device can be controlled by using I/O control.

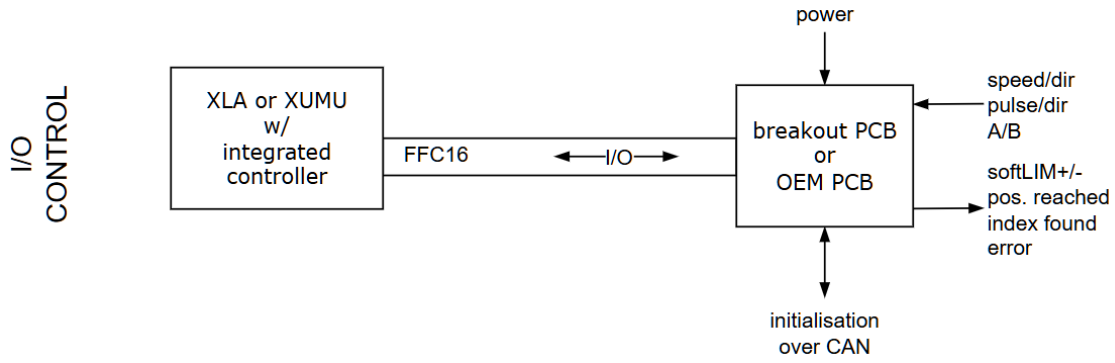

Figure 13: schematic layout when using I/O communication towards the integrated controller

This section gives an overview of the I/O functionalities of the integrated controller. Hereafter, the I/O control of the different operation modes is described.

7.1. Overview of I/O functionalities

Table 2 gives an overview of the I/O functionalities in the different operation modes. The fields marked in green are available in the current version of the firmware. Fields marked in red are not yet supported. Please contact us for more information.

Note: when daisy chaining devices, only the I/O signals of the first slave are available on the ZIF16 connection to the host/master (see pinout tables of section 3.2). The I/O signals of the other slaves are not passed on towards the host/master. I/O control of these slave devices is therefore not possible. For this reason, direct communication (CAN control) is advised when daisy chaining devices.

		Operation mode			
		Open-loop	**Velocity**	**Position**	**Trajectory**
I/O	STO	yes	yes	yes	yes
	AI1/PWM	input	speed	-	-
	DI1	-	trigger	A pulse trigger	trigger
	DI2	direction	direction	B direction	-
	DI3	enable	enable	enable	enable
	DI4	-	find index/home	find index/home	find index/home
	DO1	softLIM- A	softLIM- A	position reached softLIM- A	position reached softLIM- A
	DO2	softLIM+ B	index found softLIM+ B	index found softLIM+ B	index found softLIM+ B
	DO3	I	trigger out I	trigger out I	trigger out I
	DO4	error	error	error	error

Table 2: overview of the I/O functionalities in the different operation modes

7.2. I/O control of the different operation modes

General I/O for different operation modes

Digital inputs DI1–DI4 and digital outputs DO1–DO4 are configurable via CAN (CANopen). Each I/O can be assigned to different functions or disabled as required. Inputs can also be overridden via CAN.

STO:

- Safe Torque Off function, pin needs to be pulled high in order to enable motion

DI3:

- Enable input

D04:

- Error output

Open-loop mode

In the open-loop operation mode, the device is controlled by an input signal that modulates the motor force and speed. There is no encoder-based feedback control. Modulation of the motor power is realised by changing the piezo excitation signal.

Feedback: encoder feedback for end-of-stroke detection or external control loop in case of XLA-INTG, no feedback in case of XUMU-INTG.

AI1/PWM1: 'speed' input signal

- Analog:
  - 0 - 100% corresponds to 0.825 - 2.475 V
  - 7 V AMR
- PWM:
  - 25 - 75% range
  - 200 Hz - 200 kHz (default 50 kHz)

DI2:

- Direction input signal

DO1: not for XUMU-INTG

- End-of-stroke detection positive direction (softLIM+)
- A-output signal as feedback for external control loop

DO2: not for XUMU-INTG

- End-of-stroke detection negative direction (softLIM-)
- B-output signal as feedback for external control loop

DO3: not for XUMU-INTG

- I-output signal as feedback for external control loop

Velocity mode

In the velocity operation mode, the device speed is controlled by an input signal. The encoder signals are used for velocity feedback control. When the rod position exceeds a predefined range, limit output signals are raised.

Feedback: integrated encoder

AI1/PWM1: 'speed' input signal

- Analog:
  - 0 - 100% corresponds to 0.825 - 2.475 V
  - 7 V AMR
- PWM:
  - 25 - 75% range
  - 200 Hz - 200 kHz (default 50 kHz)

DI1:

- Trigger signal to start predefined motion profile

DI2:

- Direction input signal

DI4:

- Find index/home input signal to initiate indexing or to move to home position after indexing

DO1:

- End-of-stroke detection in negative direction based on encoder readout (softLIM-)
- A-output signal for monitoring purposes or encoder follower mode

DO2:

- Index_found output signal for indexing status
- End-of-stroke detection in positive direction based on encoder readout (softLIM+)
- B-output signal for monitoring purposes or encoder follower mode

DO3:

- Trigger out signal: user-defined trigger output signal (trigger start, pitch, width, number of triggers)
- I-output signal for monitoring purposes

Position mode

In the position operation mode, the device position is controlled by A/B or pulse/direction input signals. The encoder signals are used for position feedback control. Profile speed, acceleration and jerk can be defined. Different output signals can be selected: (i) position reached and indexing status; (ii) limit signals; or (iii) encoder signals.

Feedback: integrated encoder

Note: I/O and CAN control can be combined. For instance, setpoints can be sent via CAN communication while encoder readout is enabled on the digital outputs. When using control via pulse/direction inputs, sending new setpoints via CAN communication remains possible.

DI1:

- A-input signal for encoder follower mode
- Pulse input signal for pulse/direction mode
- Trigger signal to start predefined motion profile

DI2:

- B-input signal for encoder follower mode
- Direction input signal for pulse/direction mode

DI4:

- Find index/home input signal to initiate indexing or to move to home position after indexing

DO1:

- Position reached output signal when target position is reached
- End-of-stroke detection in negative direction based on encoder readout (softLIM-)
- A-output signal for monitoring purposes or gantry drive

DO2:

- Index found output signal for indexing status
- End-of-stroke detection in positive direction based on encoder readout (softLIM+)
- B-output signal for monitoring purposes or gantry drive

DO3:

- Trigger out signal: user-defined trigger output signal (trigger start, pitch, width, number of triggers)
- I-output signal for monitoring purposes

Trajectory mode

Not yet supported.

8. FAQ AND TROUBLESHOOTING

See https://github.com/Xeryon-Precision/XLA-INTG_prog_examples/blob/main/FAQ.md

9. WINDOWS GUI

A Windows GUI for basic configuration and control is in development. Please contact us for more information on the expected release date.

10. PYTHON, MATLAB, C++ AND LABVIEW

Currently only support for Python is available.

Please contact us for more information on the expected release dates of software support for MATLAB, C++ and LabVIEW.

11. SUPPORT

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