L-Series

Information and User Manual

Important Information When Using Our Products

Please note that Ultra Motion's commercial off-the-shelf (COTS) products are not intended for use in critical applications where failure of the product may cause bodily harm or death. Please consider the following information when designing our products into your system.

Performance

All commercial off-the-shelf products manufactured by Ultra Motion are designed to meet the performance specifications we publish in the product's manual. All life related data is provided as reference only and does not take into account application specific factors that can have significant impacts to the overall life of the product. Application specific factors can include: design loads, transient loads (shock, vibration, inertia), speed, environmental stresses (temperature, contamination), etc. Due to the fact that application specific factors can greatly affect the product's life, it is not possible to provide a generalized Mean Time Before Failure (MTBF). It is the customer's responsibility to determine the suitability of the product for their particular application.

Software

L-Series actuators have a built-in controller and are shipped with the latest release of controller firmware. The controller firmware is changed from time to time to add features, fix undesired behavior, or change how the controller operates. We do our best to thoroughly test each firmware release, but we do not guarantee that the controller firmware will be free of software problems that may cause undesirable or unpredictable behavior. It is extremely important that you test the actuator for your application and do not use the actuator in applications where the failure or unpredictable operation of the actuator may result in injury or death.

Change Control

Commercial off the shelf products are subject to changes that do not affect form, fit, or function. These changes can include the use of different PCB components, internal part revisions, suppliers, firmware, coloration, etc. Ultra Motion has the ability to track and manufacture version locked designs if your project has specific change control requirements. In a version locked design, the customer will be notified before any changes are made to their product.

Quality Control

Ultra Motion actuators are manufactured under our internal quality management system. 100% of the product we manufacture goes through a complete performance QC inspection before leaving our facility. Documented results of QC records are available to all customers.

Safety Information

IMPORTANT: Read this manual before installing and operating the Ultra Motion L-Series Servos. Failure to read this section can result in personal harm or damage to the product.

Safety Disclaimer

The L-Series is intended to be a subcomponent of a larger piece of machinery or automated system. This section is not intended to provide the safety guidelines for the entire machine or system that the servo is installed into. It is the responsibility of the purchaser or system designer to assess the risks and safety requirements of the end application they are designing.

Safety Warnings

- Once powered, the servo is capable of rapid motion and can produce large amounts of force. Always ensure that safe clearances from people and equipment are maintained before applying power.
- While the servo operates on low voltage (10 to 36 VDC recommended), you must still use caution when handling and working around the actuator to avoid electrical shock.
- The motor of the actuator can become very hot, especially at high current draws. Take adequate time to cool before handling, and provide adequate ventilation for cooling of this device.

Safety Notifications

As you read through the manual, you will notice certain safety notifications that indicate other important safety related information.

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Revision History

Revision	Date	Details
A.01	8/19/2024	Initial Release
A.02	8/30/2024	Details added throughout

L-Series Overview

The L-Series Linear Servo Actuators are advanced electromechanical actuators equipped with integrated brushless DC control electronics, CAN 2.0B and RS-485 serial communications, and our Phase Index® contactless absolute position feedback. The L-Series design focuses on dynamic operation in the most demanding environments, utilizing durable mechanical elements, top-tier materials, and best-in-class components.

The L-Series Linear Servo Actuators are powered by a high power-density Brushless DC (BLDC) motor, which is paired with a planetary gearhead to generate high torques in a compact package. This motor and gearhead assembly transmits power to a precision ground and preloaded ballscrew. Duplexed angular contact bearings handle all thrust loads and provide zero axial backlash for increased mechanical reliability and control authority.

The L-Series' design lends itself well to a dual redundant implementation with redundant motors, control electronics, and a triplicated absolute position sensor for majority voting. Our redundancy concept provides complete control over the redundant operation to the user with no arbitration, voting, or redundancy decisions made by the actuator. There is no internal communication between the redundant controllers or the triplicated sensor, they are 100% electrically isolated. The user's host can choose to use the redundant actuator in a cold-standby or load sharing arrangement. CAN 2.0B and RS-485 serial communication allow for complete control over the actuator's position and phase currents while also providing detailed telemetry regarding the actuator's health and state. An optically isolated enable input is provided as a hardware disable that removes power from the motor bridge when inactive, bypassing the onboard control electronics completely.

Typical Applications:

Aerospace, defense, industrial, and maritime applications requiring:

- Robust, high performance linear servo actuation in harsh environments
- High power density for small space envelopes
- Zero axial backlash operation for increased control authority, stiffness, and reliability
- Integrated BLDC control with CAN and serial command protocols
- Dual redundant option for single electrical fault tolerance

Features:

- Peak forces up to 800 lbf
- Peak speeds up to 5 in/s
- 1.75" and 3.125" strokes standard
- Preloaded axial load path for zero backlash
- Contactless, high resolution absolute position feedback
- Built-in brushless DC control electronics
  - CAN 2.0B, RS-485 Serial control modes
  - 10 to 36 VDC operating voltage range
- -40°C to +100°C operating temperature range
- Series-5 D38999 Connectors
- IP67 Sealing, all joints O-ring sealed with a spring energized PTFE shaft seal
- All faying surfaces chem-filmed for continuous electrical enclosure and EMI/EMC protection
- Dual Redundant versions available for single electrical fault tolerance

Product Numbers and Ordering Codes

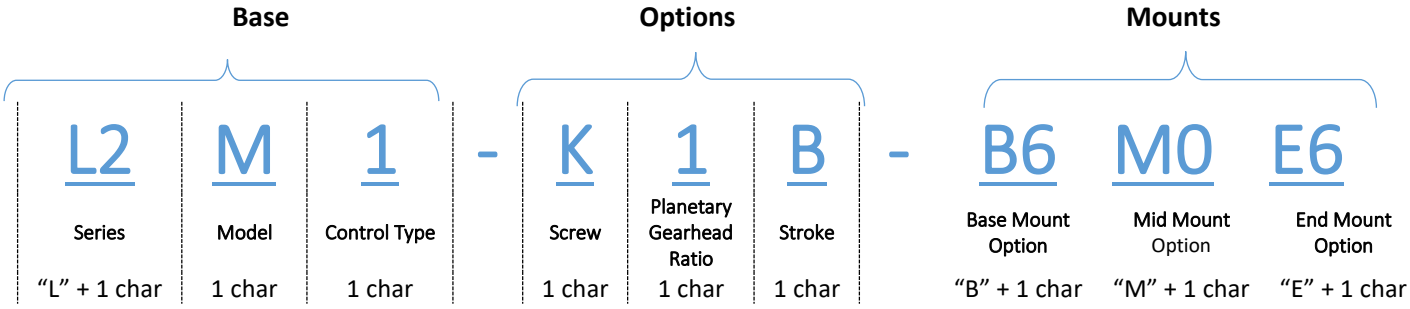
The ordering code of the L-Series Linear Servo, also known as a model number, represents all options selected for that specific model. You may determine the ordering code of a Linear Servo model based on the information in this section. The ordering code utilizes characters which represent the series, model, control type, and options for the actuator you are specifying. The characters and options available are elaborated upon further in this section.

Product Number Structure

Use the following diagram to help determine the individual features called out within the ordering code. Further in this section, a full description of all available options can be found further in this section.

This example ordering code given here describes an L2-Series "Linear Servo"

Example Ordering Code L2M1 – K1B – B6M0E6:



Series

Code	Characteristics
L1	1.02" [26 mm] width 200 lbf peak
L2	1.44" [36.6 mm] width 800 lbf peak

Models

These are the model variations available for a given series.

Code	Characteristics
M	Standard model
D	Dual redundant – 2x motors, 2x controllers, 3x absolute position sensor

Control Type

Control type defines the available control modes in the actuator.

Code	Control	Limitations
1	CAN 2.0B and RS-485 serial with enable input	-

Screw Options

Code	Description	Limitations
H	2 mm lead ballscrew, ground, light preload	L1 only
J	3 mm lead ballscrew, ground, light preload	L2 only
K	4 mm lead ballscrew, ground, light preload	L2 only

Planetary Gearhead Ratio

Code	Description	Limitations
1	11:1 (absolute reduction 87/8)	-
2	16:1 (absolute reduction 261/16)	-
3	24:1 (absolute reduction 957/40)	Non-standard, force limitations

Stroke Options

Code	Description	Limitations
A	1.75 Inch Stroke	-
B	3.125 Inch Stroke	-
D	7.5 Inch Stroke	-

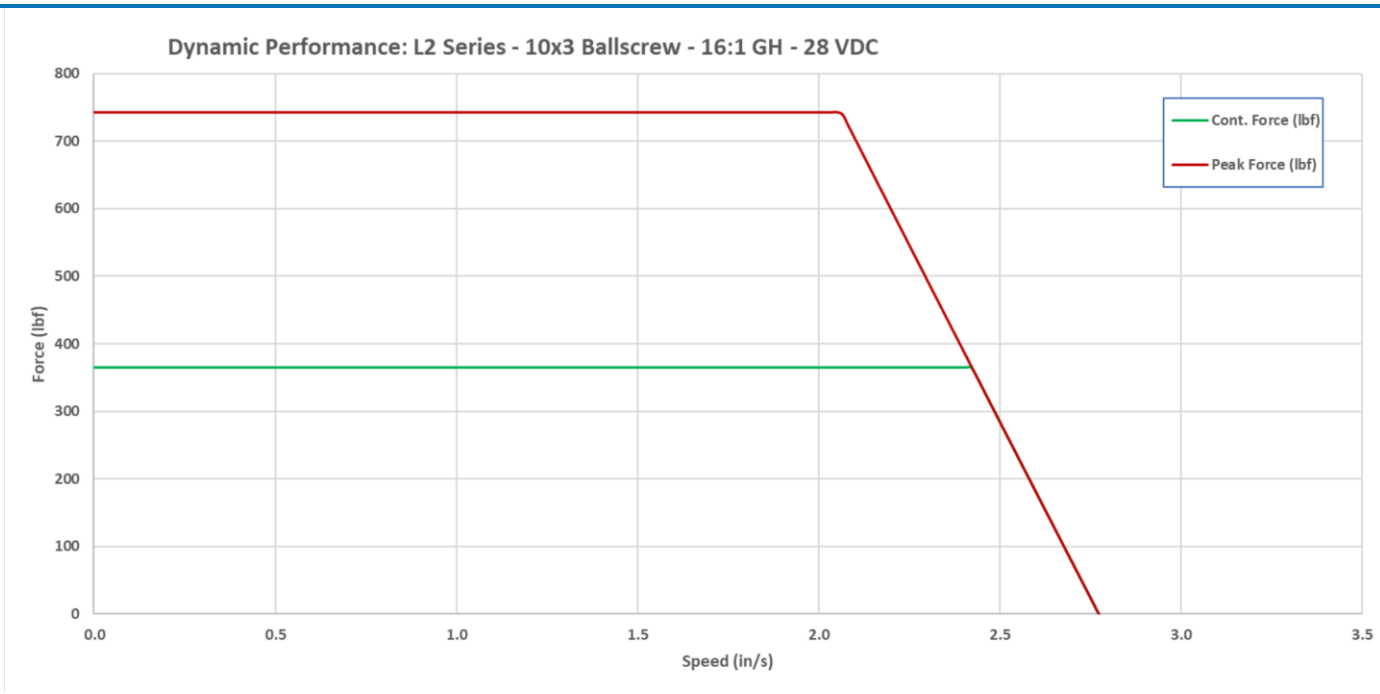
Table 1: Part number option descriptions

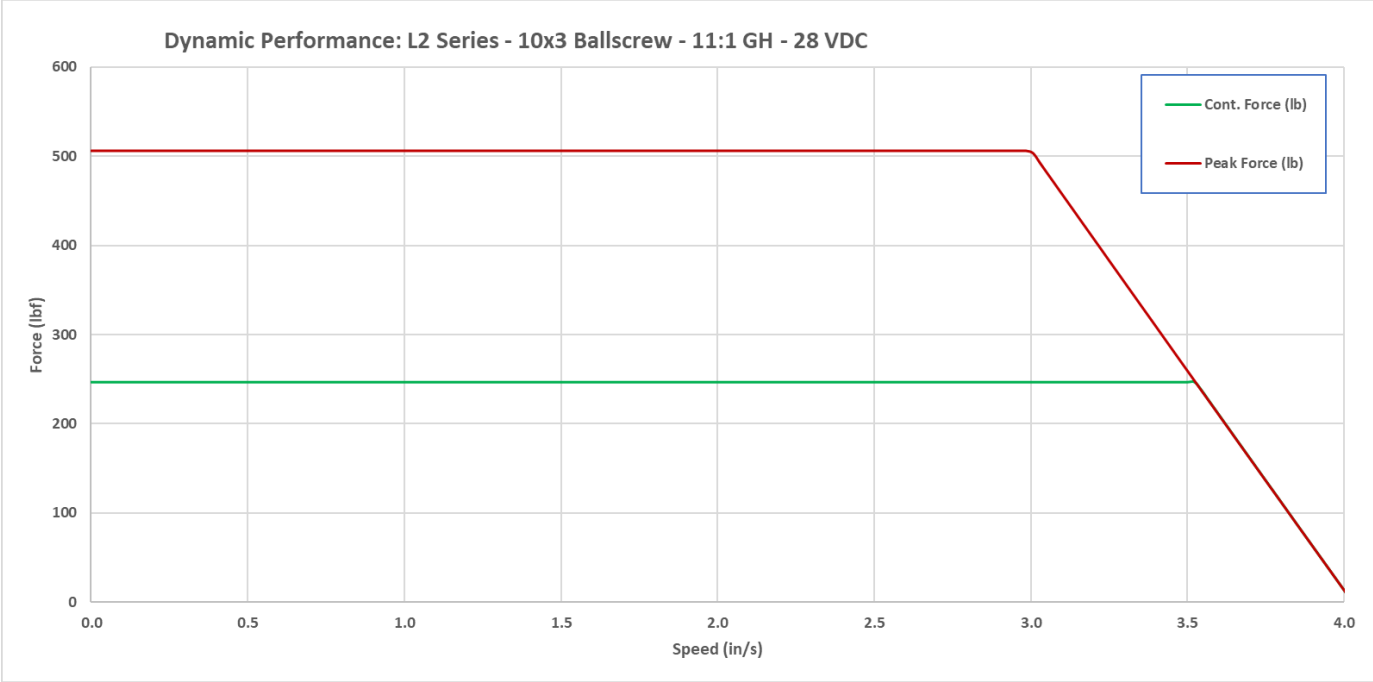
L2 Specifications:

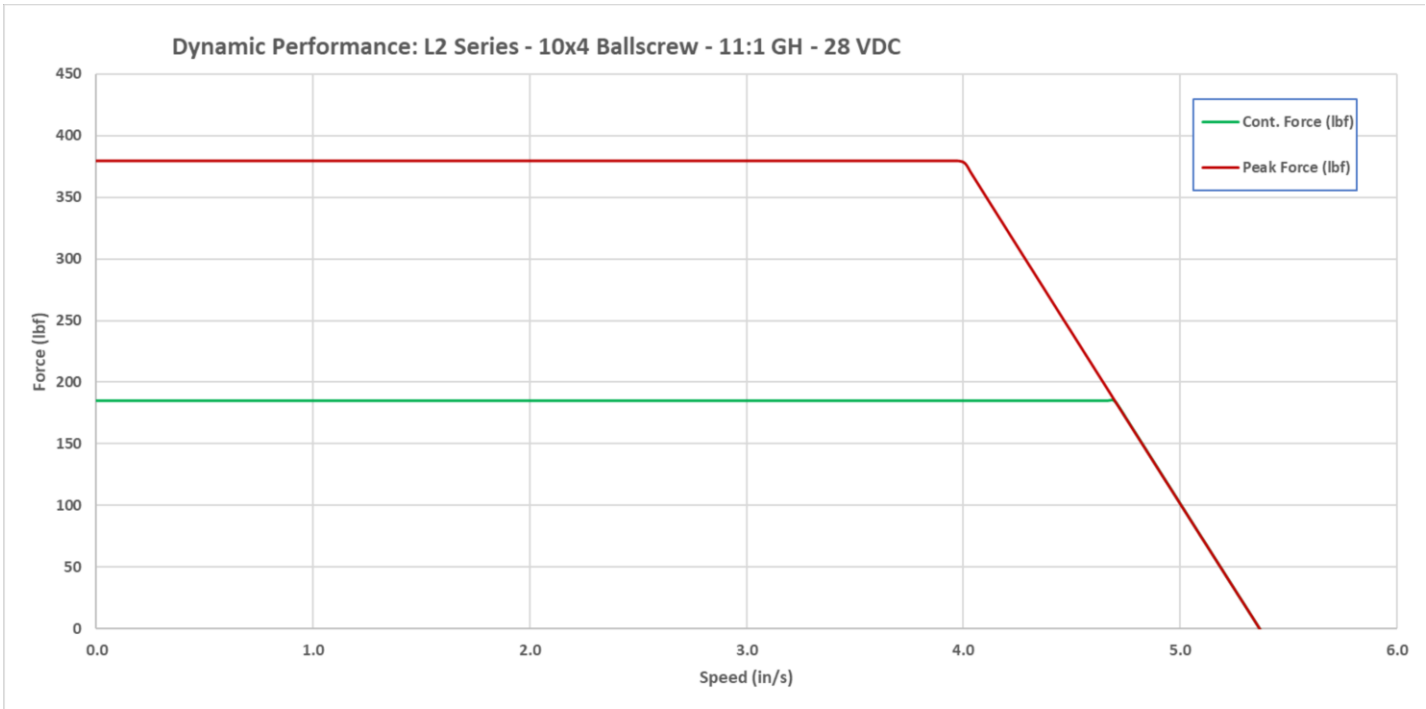
Operating Voltage	10 to 36 VDC
Absolute Maximum Voltage	62 VDC
Operating Temperature Range	-40°C to +100°C
Mass	3.0 lbm (3.125 Inch Stroke)
Standard Stroke Lengths	1.75” and 3.125”
Nominal Backlash	0 (Preloaded)
Communication Protocols	CAN 2.0B, RS-485 Serial
Environmental Sealing	IP67

Table 2: L2 Specifications

L2 Performance:







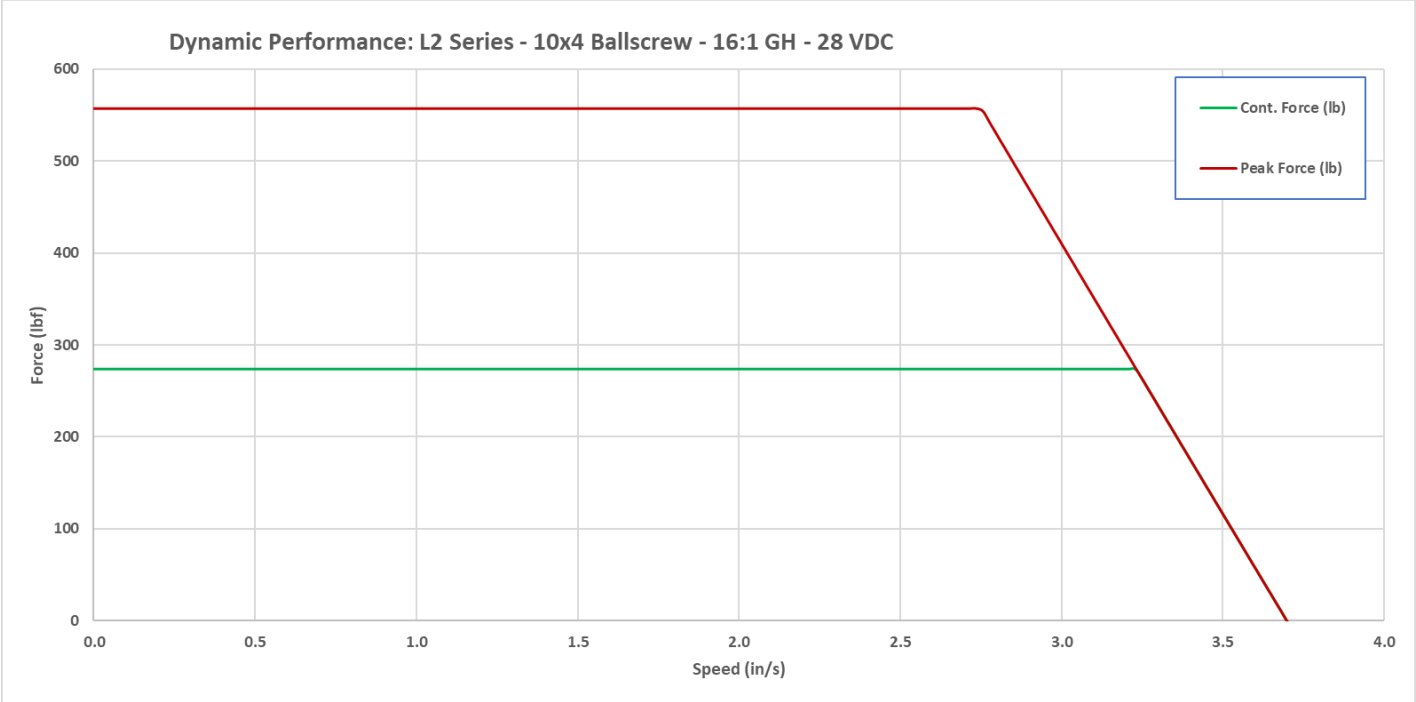
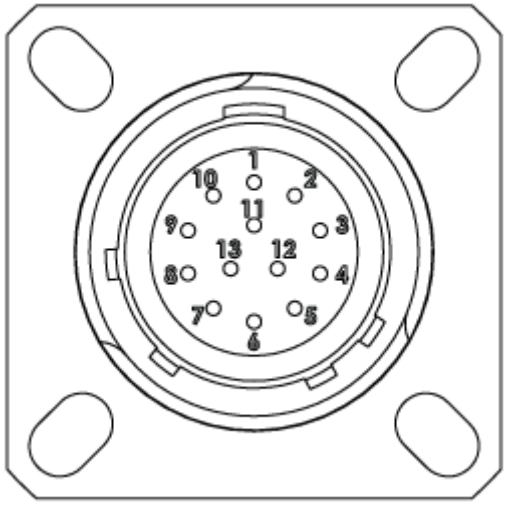


Figure 1: L2 performance graphs for various configurations

L-Series Electrical Interface

*WARNING: The electrical interface and pinouts vary between the actuator controller models. Using an improperly wired cable **will** damage to the actuator. Always be aware of your controller and its electrical interface before using the actuator.*



S500DZ-10-35PN Series-5 D38999 Receptacle

	Pin No.	Function
Power and Signal	1	GND
	2	EN+
	3	EN-
	4	RS-485B
	5	CAN_H
	6	CAN_L
	7	GND
	8	V+
	9	V+
	10	GND
	11	GND
	12	RS-485A
	13	GND
	SHELL	CHASSIS

Table 3: L-Series standard pinout

*The Series-5 D38999 connectors are not interchangeable with Series-III D38999 connectors.
**Contact Ultra Motion engineering if alternative pinouts, connectors, parallelized CAN signals, or other electrical modifications are required in your application.

L2 Dimensions

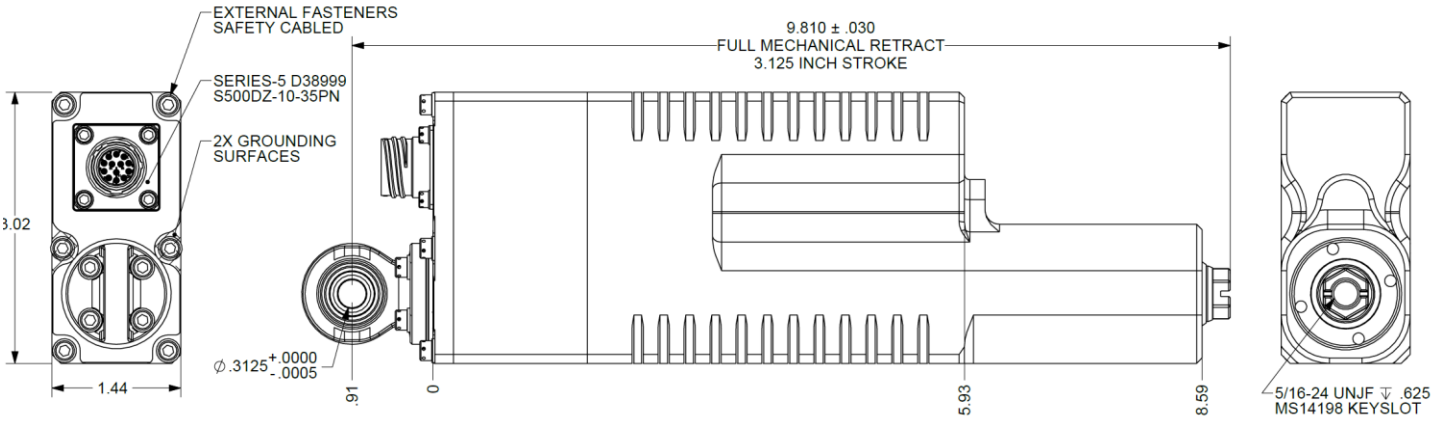


Figure 2: L2-Series dimensional drawing

Contact Ultra Motion for information regarding custom mechanical housings, mounting arrangements, connectors, or any other modifications required to suit your application's requirements.

L-Series Enable Input

The L-Series [Controller Option 1] has an optically isolated digital input that is used to directly enable/disable the servo's bridge driver IC. The enable input bypasses the actuator's microcontroller, providing the user the ability to directly disable the motor and easily backdrive the actuator when equipped with a ballscrew.

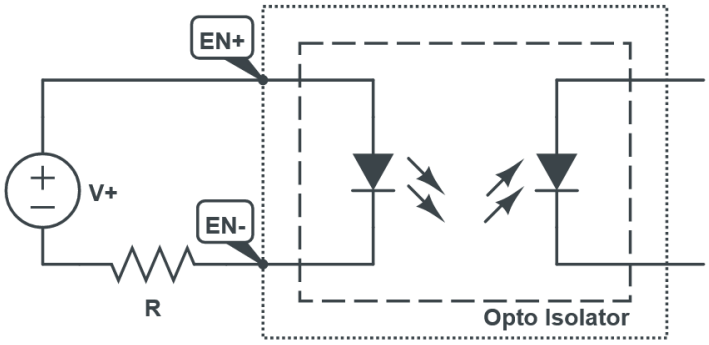


Figure 3: L-Series optically isolated digital input schematic

The controller includes a 2.7 kΩ resistor in series with the enable input. The digital inputs need to be energized with a forward current between 4 mA and 15 mA to be activated. This can be achieved with a voltage between 12 VDC and 40 VDC with a recommended nominal energizing voltage of 24 VDC.

Behavior Notes:

- An active enable input allows power to the motor, an inactive enable input removes all power from the motor bridge via a dedicated hardware switch.
- The actuator will set the position setpoint to the current absolute position on the transition from disabled (inactive) to enabled (active).
- An inactive enable input disables the overvoltage dynamic braking functionality in hardware because the bridge driver is electrically disabled. There will be no dynamic braking on a sensed bridge voltage > 55 VDC even with ovbOn = 1. Consider adding shunt electronics to protect the bus against high voltage spikes due to energetic backdriving events.

Temperature Derating

The maximum continuous load rating of the L-Series is related to the rate of heat generation by the motor and the maximum operating temperature of the actuator components. As such, when environmental temperature increases, the maximum continuous load rating of the actuator must decrease accordingly. A derating factor C_T is applied to the value for the nominal temperature maximum continuous load rating at (F_{nom}) to determine the maximum continuous load rating (F_T) for the actual operational ambient temperature:

$$F_T = F_{nom} \times C_T$$

The derating factor C_T is a function of the nominal temperature at which the maximum continuous load rating actuator is defined (T_{nom}= 22°C for the L-Series), the maximum permissible winding temperature of the actuator (T_{max}, = 150°C), and the ambient temperature of the application to which you are derating ($T_{ambient}$).

$$C_T = \sqrt{\frac{T_{max} - T_{ambient}}{T_{max} - T_{nom}}} = \sqrt{\frac{150°\text{C} - T_{ambient}\,(°\text{C})}{150°\text{C} - 22°\text{C}}} = \sqrt{\frac{302°\text{F} - T_{ambient}\,(°\text{F})}{302°\text{F} - 71.6°\text{F}}}$$

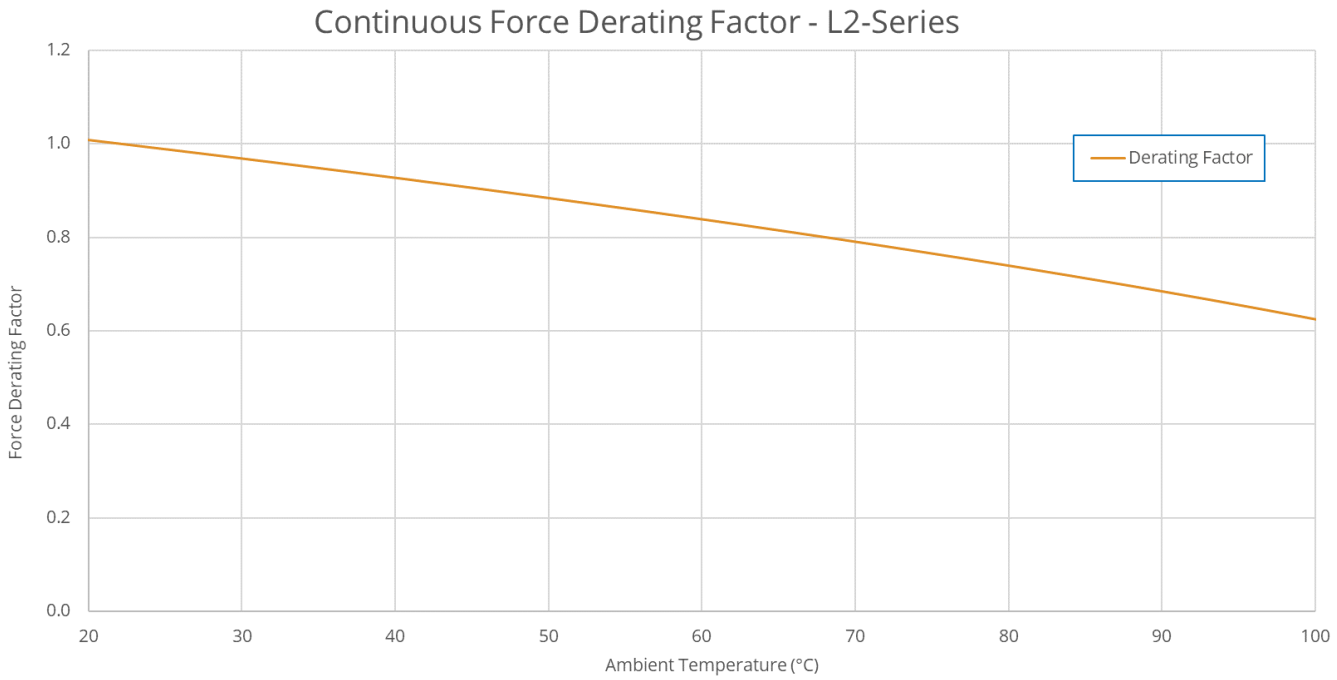


Figure 4: Derating factor for maximum continuous load C_T as a function of temperature.

The following reference document details Ultra Motion's controller and firmware for the L-Series Linear Servo Actuators

L-Series Controller Configuration Overview

This section provides an overview of how to configure the L-Series controller. All configuration variables can be read or written via the RS-485 interface and saved to non-volatile memory.

The RS-485 interface is half-duplex and non-addressable. Contact Ultra Motion engineering regarding addressable RS-485 serial protocols.

Read Variable

The current value in RAM for all configuration variables can be read via the RS-485 interface with the 'RV" command followed by the case-sensitive configuration variable name. E.g. reading the operating mode can be accomplished with the command "RV opMode". Issuing the "RV" command with no argument will show all the available configuration variables.

Write Variable

All configuration variables can be overwritten via the RS-485 interface with the 'WV" command followed by the case-sensitive configuration variable and the desired setting. E.g., setting the operating mode to 1 can be accomplished with the command "WV opMode 1"

Save Configuration

The WV command will only change the variable in RAM, the configuration must be saved to non-volatile memory with the "CW321" command in order to maintain the changes after power-cycle or reset.

L-Series CAN Behavior/Configuration

This section provides an overview of the L-Series CAN firmware configuration options and behavior.

Operating Mode

The operating modes for this firmware include command line interface control via RS-485 serial, and CAN control. The operating mode can be set via the opMode configuration variable.

opMode = 0 enables motion control through the RS-485 serial Command Line Interface

opMode = 1 enables motion control through CAN 2.0B position command messages

Command Line Interface Lock

The L-Series will start-up with the CLI locked when the cliLock variable is set to 1, which means no received serial commands will be executed. This is to protect the actuator from executing erroneous commands due to noise or user error. To use the command line interface the special command "LK" with the argument "unlock" is required (i.e. "LK unlock\r"). The actuator's CLI will lock after every power cycle unless the configuration variable cliLock is set to zero.

CAN Baud Rate

The L-Series' CAN baud rate is definable with the CANspd variable. Values of 0 to 7 are acceptable and defined as follows:

CANspd =

0: 1 Mbps
1: 500 Kbps
2: 250 Kbps
3: 125 Kbps
4: 100 Kbps
5: 50 Kbps
6: 20 Kbps
7: 10 Kbps

CAN Message Type

The firmware will support either 11-bit (standard) or 29-bit (extended) identifiers, settable with the CANext variable.

CANext = 0: Standard message type (11-bit identifier)

CANext = 1: Extended message type (29-bit identifier)

rxID

rxID is the actuator's network address and is used along with rxMask to filter incoming CAN command messages. For acceptance, the message's identifier must match rxID where each corresponding bit in rxMask is set to '1'. If CANext = 0, only the lower 11 bits of rxID and rxMask are examined (standard message type). If CANext is 1, the lower 29 bits of rxID and rxMask are examined (extended message type). Configuration is accomplished with the rxID variable. rxID can be any value from 0x00000000 to 0x1FFFFFFF.

rxMask

rxMask is used along with rxID to filter incoming CAN command messages. For acceptance, the message's identifier must match rxID where each corresponding bit in rxMask is set to '1'. If a bit in rxMask is set to '0', the corresponding bit of an incoming can message is matched for acceptance regardless of its value. If rxMask is set to 0x00000000, CAN messages with any identifier will be accepted. If rxMask is set to 0x1FFFFFFF, only CAN messages with an identifier that

exactly matches the relevant bits of rxID will be accepted. If CANext = 0, only the lower 11 bits of rxID and rxMask are examined (standard message type). If CANext is 1, the lower 29 bits of rxID and rxMask are examined (extended message type). Configuration is accomplished with the rxMask variable. rxMask can be any value from 0x00000000 to 0x1FFFFFFF.

Command Message Data Format

The L-Series can receive up to 8 data bytes in each position command message from the master controller. The rxData variable is a string with a maximum length of 8 characters where each character designates a byte of data in the command message. The actuator must be configured to receive a position command.
The data format for received CAN position command messages is configured with the rxData configuration variable.

Command Message Data Format

Char	Description
<	Position command LSB
>	Position command MSB
(	Max motor current LSB
)	Max motor current MSB
X	Ignore byte
x	Ignore byte

Table 4: Command options for the CAN 2.0B protocol used in rxData

The default value of rxData = "<>" requires the user to send a CAN message with 2 data bytes containing the LSB of the position command as the first data byte in the message, and the MSB of the position command as the second data byte. Note that setting the max motor current to a low value does not lead to a freely backdriveable actuator with the L-Series and will instead cause a dynamic braking behavior. The actuator's enable input must be de-energized, or the startup/timeout action set to COAST the motor, in order to allow the actuator to backdrive freely.

Position Interpolation

A position interpolation function provides smooth motion between each position update. The smoother motion provided by the interpolator increases mechanical reliability and the actuator response.
Interpolation can be enabled/disabled with the inEna configuration variable.

inEna = 0 disables interpolation
inEna = 1 enables interpolation

Interpolation Period

The interpolation period can be set with the canIvl variable. This variable is set in 1 ms increments and should be set equal to the expected position update interval from the master controller. If the update rate cannot be matched exactly, setting the interpolation interval slightly larger than the expected update interval is recommended. The default value of canIvl is 50. This value is equal to a 50 ms update interval (20 Hz update frequency).

Default Start Position

The L-Series can be configured to drive to a default position on startup before receiving a valid CAN message, or on failure of the CAN bus leading to a timeout event. These events would execute a trajectory move to the position defined by defPos with trajectory parameters defined by the maxSpeed and accel configuration variables. As an example, the defPos variable could be set to a control surface's neutral position. The default position can be set with the defPos configuration variable. The units are in Phase Index absolute position encoder counts.

Received Message Timeout

The received message timeout period can be set with the canTO configuration variable. This variable is set in 1 ms increments. The default value is 1250 (1.25 seconds). When a timeout occurs, the appropriate status register bit (bit 40) will become active and the actuator's timeout behavior (set by cTOact) will initiate. The actuator will not execute the timeout action if no valid CAN command frames have been received after powerup.

Timeout Action

The L-Series can be configured for different behaviors after a CAN timeout event

- cTOact = 0 Holds the last valid position with the last valid max motor current command
- cTOact = 1 Executes a trajectory move to the default position defPos with the last valid max motor current
- cTOact = 2 COAST the motor
- cTOact = 3 Dynamic brake the motor
- cTOact = 4 Holds the last valid position with the configured maxCurr setting
- cTOact = 5 Executes a trajectory move to the default position defPos with the configured maxCurr setting

The timeout action can be set with the cTOact configuration variable.
The timeout action will not occur if no valid CAN command frames have been received after powerup. At least one valid CAN command frame must be received for the timeout action to take place.

Startup Action

The L-Series can be configured for different behaviors at startup before receiving the first valid CAN command frame.

- cSUact = 0 holds the current position
- cSUact = 1 executes a trajectory move to the default position defPos
- cSUact = 2 COAST the motor
- cSUact = 3 Dynamic brake the motor

The startup action can be set with the cSUact configuration variable.

L-Series Telemetry

The L-Series can send user-configurable telemetry messages over the CAN bus with a configurable ID. There are three independent telemetry messages that can be configured with separate identifiers, data, and update rates.

Telemetry Enable

The txEna configuration variable is used to turn on/off the L-Series CAN telemetry transmit functionality. The least significant 3 bits correspond to the 3 telemetry messages with bit0 as tx1Ena, bit1 as tx2Ena, and bit2 as tx3Ena.
Example settings for txEna:

- txEna = 0 disables telemetry
- txEna = 6 (0b110) activates telemetry messages 2 and 3
- txEna = 7 (0b111) activates all 3 telemetry messages

Telemetry Interval

The rate at which the L-Series transmits the telemetry CAN message is configurable and set by editing the txNIvl variable. The setting is in milliseconds and has a valid range of 2 to 10,000. Care must be taken to not overload the CAN bus by setting the interval value too low. The default values are tx1Ivl = 1000, tx2Ivl = 2500, and tx3Ivl = 5000.

Telemetry Message ID

The txNID variable sets the CAN identifier for the transmitted CAN telemetry message. This represents the destination address of the telemetry message. Either the lower 11 bits (standard) or the lower 29 bits (extended) of txNID are used depending on CAN bus message type setting (CANext). The user can specify the ID in decimal or hex if preceded with "0x". txNID can be any value from 0x00000000 to 0x1FFFFFFF, the default values are tx1ID = 0x0000007F, tx2ID = 0x0000027F, tx3ID = 0x0000037F.

Telemetry Message Data Format

The data bytes of each telemetry message are configurable with the txNData configuration variables. The txNData variables are strings where each character designates a variable in the telemetry message. txNData may be 1 to 8 characters in length, but the total number of resulting data bytes cannot exceed 8 for a single message.

Telemetry Message Data Format

Char	Description	Type	Num Bytes	Available via RS485
A	ID Byte	UINT8	1	Yes
B	Critical Errors Byte	UINT8	1	Yes
C	Warning Byte 0	UINT8	1	Yes
D	Warning Byte 1	UINT8	1	Yes
E	Warning Register – Clear on Broadcast	UINT16	2	Yes
F	CAN Position Command	UINT16	2	Yes
G	Position Demand	UINT16	2	Yes
H	Motor Current Demand	INT16	2	Yes
I	Motor Current Demand Limit	UINT16	2	Yes
J	Duty Cycle Out	INT16	2	Yes
K	Encoder Position Feedback	UINT16	2	Yes
L	Hall Position Feedback	UINT16	2	Yes
M	Encoder Velocity Count	INT16	2	Yes
N	Encoder Velocity Interval	UINT32	4	Yes
O	Motor Current – Instantaneous	INT16	2	Yes
P	Motor Current – Average over interval	INT16	2	No
Q	Motor Current – Minimum over interval	INT16	2	No
R	Motor Current – Maximum over interval	INT16	2	No
S	Bridge Current – Instantaneous	UINT16	2	Yes
T	Bridge Current – Average over interval	UINT16	2	No
U	Bridge Current – Minimum over interval	UINT16	2	No
V	Bridge Current – Maximum over interval	UINT16	2	No
W	Bridge Voltage – Instantaneous	UINT16	2	Yes
X	Bridge Voltage – Average over interval	UINT16	2	No
Y	Bridge Voltage – Minimum over interval	UINT16	2	No

Z	Bridge Voltage – Maximum over interval	UINT16	2	No
a	Supply Voltage – Instantaneous	UINT16	2	Yes
b	Supply Voltage – Average over interval	UINT16	2	No
c	Supply Voltage – Minimum over interval	UINT16	2	No
d	Supply Voltage – Maximum over interval	UINT16	2	No
e	Status Register Byte 0	UINT8	1	Yes
f	Status Register Byte 1	UINT8	1	Yes
g	Status Register Byte 2	UINT8	1	Yes
h	Status Register Byte 3	UINT8	1	Yes
i	Status Register Byte 4	UINT8	1	Yes
j	Status Register Byte 5	UINT8	1	Yes
k	Status Register Byte 0 – Latched High	UINT8	1	No
l	Status Register Byte 1 – Latched High	UINT8	1	No
m	Status Register Byte 2 – Latched High	UINT8	1	No
n	Status Register Byte 3 – Latched High	UINT8	1	No
o	Status Register Byte 4 – Latched High	UINT8	1	No
p	Status Register Byte 5 – Latched High	UINT8	1	No
q	Status Register Byte 0 – Latched Low	UINT8	1	No
r	Status Register Byte 1 – Latched Low	UINT8	1	No
s	Status Register Byte 2 – Latched Low	UINT8	1	No
t	Status Register Byte 3 – Latched Low	UINT8	1	No
u	Status Register Byte 4 – Latched Low	UINT8	1	No
v	Status Register Byte 5 – Latched Low	UINT8	1	No
w	PCB Temperature (2 Hz update)	UINT8	1	Yes
x	PCB Relative Humidity (0.25 Hz update)	UINT8	1	Yes
y	PCB Temp2 (0.25 Hz update)	UINT8	1	Yes
z	PCB Temperature – 32 bits (2 Hz update)	FLOAT32	4	Yes
3	PCB Humidity – 32 bits (0.25 Hz update)	FLOAT32	4	Yes
4	PCB Temp2 – 32 bits (0.25 Hz update)	FLOAT32	4	Yes
6	Position PID I-Term	INT16	2	Yes
7	Serial Number	UINT32	4	Yes
8	UART Status Register	UINT16	2	Yes
9	CAN Errors (MSB = TX errors, LSB = RX errors)	UINT16	2	Yes

Table 5: Telemetry options for the CAN 2.0B protocol used in txNData

The telemetry message may include anywhere from 1 to 8 bytes of data and they can be any combination of the above options. Latched status bytes are reset after they are transmitted. Latched low bytes are reset high, and latched high bytes are reset low. Values that are average or min/max over the telemetry interval are also reset after they are transmitted. Values that are reset after they are transmitted should only be accessed from one telemetry message; either tx1Data, tx2Data, or tx3Data, but never more than one at the same time.
Since status bits are tested one time every millisecond, a status bit event lasting less than one millisecond may not be latched.
The default values are: tx1Data = “GKPCD”, tx2Data = “klmnpb”, and tx3Data = “wxy”.

System Errors Register

The System Errors Register contains error status bits that result in automatic entry into safe-mode (motor OFF) when set.

System Error Register

Error Bit	Bit Description
0	Configuration not loaded
1	Invalid Configuration in NVM
2	Bridge driver IC initialization failure
3	Phase Index encoder initialization failure
4 to 7	Reserved

Table 6: System Errors Register bit descriptions

System Warning Register

The System Warning Register contains error status bits that do NOT result in automatic safe-mode (motor OFF).

System Warning Register

Warning Bit	Bit Description
0	Bad configuration block in memory, majority of redundant copies are valid
1	Invalid configuration
2	Erroneous reset
3	Bridge enable switch fault
4	Humidity/temperature sensor error
5	FRAM error
6	UART error
7	Phase Index sensor communication error
8	Bridge driver IC fault
9	Hall sensor error
10	Phase error above threshold
11	Phase Index QEI error
12	Phase Index encoder diagnostic error
13	Voltage high (> 55 VDC)
14	CAN initialization error
15	CAN transmit error

Table 7: System Warnings Register bit descriptions

System Status Register

The status register bytes contain bits that represent different aspects of the L-Series health and state. The configurable telemetry options include latched and non-latched versions of the individual status bytes.

Status Byte	Bit	Status Bit#	Description
0	0	0	Nominal 3.3 V bus
0	1	1	Nominal 5.0 V bus
0	2	2	Nominal 7.5 V bus
0	3	3	Bridge voltage > Input voltage (regen occurring)
0	4	4	Bridge voltage less than minimum (9 VDC)
0	5	5	Bridge voltage greater than maximum (55 VDC)
0	6	6	Input voltage less than minimum (9 VDC)
0	7	7	Input voltage greater than maximum (55 VDC)
1	0	8	Safe Mode, MOTOR OFF
1	1	9	State of the optically isolated enable input
1	2	10	Bridge is active
1	3	11	Bridge driver IC fault
1	4	12	Bridge enable switch fault
1	5	13	Motor current demand capped at maxCurr
1	6	14	Motor current feedback greater than ovCurr
1	7	15	Trajectory move is active
2	0	16	System error register is non-zero
2	1	17	System warning register is non-zero
2	2	18	Temperature at PCB is greater than ovTemp value
2	3	19	Temperature at PCB is less than unTemp value
2	4	20	Humidity at PCB greater than ovHumd value
2	5	21	Phase Index health status (0 = healthy)
2	6	22	Encoder phase error warning limit exceeded
2	7	23	Phase Index to QEI difference exceeded
3	0	24	Absolute position less than or equal to rPos
3	1	25	Absolute position greater than or equal to ePos
3	2	26	Absolute position less than spMin
3	3	27	Absolute position greater than spMax
3	4	28	Absolute position less than posLe
3	5	29	Absolute position greater than posGr
3	6	30	Actuator stopped
3	7	31	Direction of travel is extend
4	0	32	CAN RX error counter > 0 and < 127
4	1	33	CAN TX error counter > 0 and < 127
4	2	34	CAN RX Warning
4	3	35	CAN TX Warning
4	4	36	CAN RX error passive state
4	5	37	CAN TX error passive state
4	6	38	CAN TX Bus Off
4	7	39	CAN TX error flag
5	0	40	CAN RX Timeout Flag
5	1	41	CAN position command capped low at pMin
5	2	42	CAN position command capped high at pMax
5	3	43	Overvolt braking is active
5	4	44	Dynamic braking off (0 = brake on, 1 = brake off)
5	5-7	45-47	Reserved

Table 8: Status Register bit descriptions

L-Series Event Based Asynchronous CAN Messages

The L-Series can be configured to transmit CAN messages on the occurrence of asynchronous events.

The asynchronous event message frames will all have 8 data bytes with the following format:

CAN Frame Data Byte	Byte Description
0	IDbyte (configuration variable, should be set to a unique value for each actuator on the bus)
1	Event Code
2-7	Event Data Bytes 0-5

Table 9: Asynchronous Message Format

Configuring Event Messages

The actuator will broadcast event messages on the CAN bus with an address defined by evntID

There are two separate configuration variables used to enable event message broadcasts, one for system warning events, and one for non-critical “miscellaneous” events.

Warning events occur when a warning bit transitions from low to high. After a warning message is sent for a particular warning bit, a timer with the value of evntIvl milliseconds must expire before another message for the same bit can be re-broadcast.

Warning event messages are enabled with the evntWrn configuration variable. Setting a bit high in evntWrn enables event messages for the corresponding bit in the system warning register. The warning bit will clear after the warning event message is broadcast if the corresponding “clear” bit in the evntWrnC mask is high. If the clear bit is low, the warning bit will remain unchanged by the event message broadcast. If the warning bit is not cleared, the warning event will not reoccur.

The evntMsc configuration variable works the same way as evntWrn with each bit in the mask enabling a pre-defined event message. The events in evntMsc are not constrained by a minimum rebroadcast time as the warning events are.

Table 10 and Table 11 detail the pre-defined event messages that can be enabled with evntWrn and evntMsc:

System Event Details

The following tables detail the possible asynchronous event messages. Please contact Ultra Motion engineering for details regarding the various event data.

Event Code	evntWrn bit	Warning Event Cause	Warning Event Data Bytes (6 bytes)
0	0	Bad configuration block in NVM	byte 0-5: unused
1	1	Configuration error	byte 0-1: 16bit Config Content Error Code
2	2	Erroneous reset	byte 0-1: 16bit Reset Cause byte 2-5: 32bit Error Address
3	3	Bridge enable switch fault	byte 0-1: 16bit Input Voltage Sense byte 2-3: 16bit Bridge Voltage Sense
4	4	Humidity sensor comm error	byte 0-1: 16bit Sensor Error Code
5	5	FRAM error	byte 0-5: unused
6	6	UART error	byte 0-1: 16bit UART Status byte 2-3: 16bit UART Error Count
7	7	Phase Index sensor comm error	byte 0-1: 16bit Primary Parity Error Count byte 2-3: 16bit Secondary Parity Error Count byte 4-5: 16bit Primary Error Bit Count
8	8	Bridge driver fault	byte 0-1: 16bit Bridge Fault Count byte 2-3: 16bit Bridge Fault Register [1] byte 4-5: 16bit Bridge Fault Register [2]
9	9	Hall sensor error	byte 1-2: 16bit Invalid Hall State Count byte 3-4: 16bit Invalid Hall Sequence Count
10	10	Phase error above threshold	byte 0-1: 16bit Phase Index Phase Error byte 2-3: 16bit Phase Index to QEI Error byte 4-5: 16bit Encoder Error Position
11	11	Phase Index encoder error	byte 0-1: 16bit Phase Index Phase Error byte 2-3: 16bit Phase Index to QEI Error byte 4-5: 16bit Encoder Error Position
12	12	Encoder diagnostic error	byte 0-1: 16bit Primary Diagnostic Register byte 2-3: 16bit Secondary Diagnostic Register byte 4-5: 16bit Encoder Error Position
13	13	Voltage high (> 55 VDC)	byte 0-1: 16bit Input Voltage Sense byte 2-3: 16bit Bridge Voltage Sense
14	14	CAN initialization error	N/A
15	15	CAN transmit error	N/A

Table 10: Warning event codes, causes, and data fields

Event Code	evntMsc bit	Miscellaneous Event Cause	Miscellaneous Event Data Bytes (6 bytes)
16	0	Normal Reset (power-on or user commanded)	byte 0: 8bit System Error Register byte 1: 8bit System Status Byte1 byte 2-5: 32bit Actuator Serial Number
17	1	System Error (motor in safe mode)	byte 0: 8bit System Error Register byte 1: 8bit System Status Byte1 byte 2-3: 16bit System Warning Register byte 4-5: 16bit Config Content Error Code
18	2	Optically Isolated Enable Input Active	byte 0-5: 8bit System Status Byte0-5
19	3	Optically Isolated Enable Input Inactive	byte 0-5: 8bit System Status Byte0-5

Table 11: Miscellaneous event codes, causes, and data fields

L-Series RS-485 Serial Command Line Interface

The L-Series RS-485 serial interface is half-duplex, 8N1. A command line is parsed and executed after a carriage return byte is received by the UART. A command line consists of the following: 0 or more space or tab bytes, 2-byte ASCII command, 0 or more ASCII arguments preceded by 1 or more space or tab bytes, 0 or more space or tab bytes, carriage return byte.

The CLI will respond to a command line with the command's returned data, "OK" if the command was executed successfully but has no data to return, or "ERROR: " + *error type* if a command was not executed successfully.

Contact Ultra Motion engineering regarding addressable RS-485 protocols.

L-Series Serial Commands Quick Reference Table

Command	Description	Group	Arguments
RV	Read configuration variable	Configuration	1 or 0
WV	Write configuration variable	Configuration	2
CW	Save configuration settings to non-volatile memory	Configuration	1
CC	Copy configuration block from inactive to active partition	Configuration	1
RR	Read runtime variable	Read	1 or 0
SR	Read status register bits	Read	2 or 0
RI	Read reset information	Read	0
ZD	Read bridge driver FAULT register log	Read	0
FS	Show serial number, part number, firmware version, target PCB	Read	0
HE	Show all available serial commands	Read	0
TA	Trajectory move to absolute position	Motion Control	1
TO	Trajectory move to offset position	Motion Control	1
TR	Trajectory move to fully retracted position (spMin)	Motion Control	0
TM	Trajectory move to mid-stroke (spMin+spMax)/2	Motion Control	0
TE	Trajectory move to fully extended position (spMax)	Motion Control	0
TD	Trajectory move to the default position (defPos)	Motion Control	0
T1	Trajectory move to tPos1	Motion Control	0
T2	Trajectory move to tPos2	Motion Control	0
TK	Interrupt current trajectory move	Motion Control	0
TS	Stop trajectory at maximum acceleration	Motion Control	0
PC	Set target position to current position	Motion Control	0
PA	Set absolute target position	Motion Control	1
PO	Set target position with an offset	Motion Control	1
ZR	Restart actuator controller	System	1
LK	Lock or unlock serial command-line-interface	System	1 or 0
FW	Show firmware installed on active and inactive partitions	System	0
SA	Swap active/inactive firmware partition	System	1
ZC	Run actuator calibration utility	System	1
ZU	Run serial firmware update utility	System	1

Table 12: Serial Commands List

RV – Read Configuration Variable(s)

This command returns the value of any of the configuration variable. Sending this command with no argument returns the value of all configuration variables.

Usage: RV
Usage: RV arg1
arg1 Description: Variable name (case sensitive)
arg1 Data Type: String

WV –Write Configuration Variable

This command sets any configuration variable. To save the current configuration to non-volatile memory, use the **CW** command.

Usage: WV arg1 arg2
arg1 Description: Configuration variable name (case sensitive)
arg1 Data Type: String
arg2 Description: Value to write
arg2 Data Type: Configuration variable's data type

CW – Write Configuration Settings to Non-Volatile Memory

This command will take all current configuration settings and write them to non-volatile memory.
This must be done if a setting was changed via a serial command, and you wish to retain this change after a restart or power-cycle.

Usage: CW arg1
arg1 Description: Passcode to execute command
arg1 Data Type: Unsigned Integer
arg1 Range: "321"

CC – Copy Configuration Block from inactive to active partition

The CC command will copy the actuator configuration from the inactive partition to the active partition. This will overwrite the existing configuration block on the active partition. The command will only execute if the configuration block on the inactive partition is the same size as active partition's configuration block. This command is useful for copying the existing configuration to new firmware after a firmware update. It will only work if the configuration block layout has not changed between old firmware and new. A reset is required to load the copied configuration block after this command is executed.

Usage: CC arg1
arg1 Description: Passcode to execute command
arg1 Data Type: Unsigned Integer
arg1 Range: "321"

RR – Read Run-Time variable

Returns the value of value of any run-time variable. Running this command with no argument shows all of the available run-time variables. The value of some variables can only be read via CAN telemetry. See *Table 5: Telemetry options for the CAN 2.0B protocol used in txNData* for telemetry options accessible via serial. Sending multiple characters will return the requested variables in comma-separated-value format (e.g. RR ABC). Some variables can only be read via CAN telemetry.

Usage: RR
Usage: RR arg1
arg1 Description: One or more run-time variable character designators (see Table 5)
arg1 Data Type: String

SR – Read Status Register Bits

Returns the current value of all status register bytes when the command is sent with no arguments. Returns a particular bit within the status register selected by argument 1 (status byte number) and argument 2 (bit number).

Usage: SR
Usage: SR arg1 arg2
arg1 Description: Status Byte Number
arg1 Data Type: Unsigned Integer
arg1 Range: 0 to 5
arg2 Description: Status Bit Number
arg2 Data Type: Unsigned Integer
arg2 Range: 0 to 7

FS – Read Actuator Details

Return the actuator's serial number, part number, firmware version ID, and target PCB.

Usage: FS

HE – Show All Serial Commands

Return a list of all available serial commands and their descriptions.

Usage: HE

RI – Read Reset Information

Read information about the last CPU reset.

Usage: RI

ZD – Read Bridge Driver Fault Register Log

Returns the fault register log of the bridge driver IC.

Usage: ZD

TA – Trajectory Move to Absolute Position

Sending this command result in a trajectory move an absolute encoder position. Trajectory moves obey the maxSpeed (maximum profile speed) and accel (profile acceleration) settings.

Usage: TA arg1
arg1 Description: Absolute encoder position
arg1 Data Type: Unsigned Integer
arg1 Range: spMin to spMax

TO – Trajectory Move to Offset Position

Trajectory move to the current position + offset. The resultant position must be within the bounds defined by spMin and spMax

Usage: TO arg1
arg1 Description: Relative position offset
arg1 Data Type: Signed Integer
arg1 Range: spMin < Target Position < spMax

TR – Trajectory Move to Fully Retracted Position (spMin)

Trajectory move to spMin - "Software Position Minimum" with user defined speed and acceleration.

Usage: TR

TM – Trajectory Move to Mid-Stroke

Trajectory move to midpoint with user defined speed and acceleration. The midpoint is defined by $\frac{(spMax+spMin)}{2}$

Usage: TM

TE – Trajectory Move to Fully Extended Position (spMax)

Trajectory move to spMax - "Software Position Maximum" with user defined speed and acceleration.

Usage: TE

T1 – Preset Position 1 Trajectory Move

Initiate a trajectory move to tPos1

Usage: T1

T2 – Preset Position 2 Trajectory Move

Initiate a trajectory move to tPos2

Usage: T2

TD – Trajectory Move to the default Position

Trajectory move to defPos – "Default Position" with user defined speed and acceleration.

Usage: TD

TS – Stop Trajectory Move at Maximum Acceleration

Stop the current trajectory at the maximum acceleration rate.

Usage: TS

TK – Interrupt Current Trajectory Move

Halt the current trajectory motion at current position.

Usage: TK

PA – Set Absolute Target Position

Sending this command with a valid argument will set the current position demand register resulting in an immediate move to the new position. This command writes directly to the position demand register, bypassing the trajectory generator. This leads to a full acceleration, full speed move to the new target position which ignores maximum speed and maximum acceleration settings. Users will typically use this command for maximum dynamic performance in conjunction with an external trajectory generator. Use this command with caution.

Usage: PA arg1
arg1 Description: Absolute encoder position
arg1 Data Type: Unsigned Integer
arg1 Range: spMin to spMax

PO – Set Target Position with an Offset

Set the target position to the current position + the offset. The resultant position must be within the bounds defined by spMin and spMax. This command writes directly to the position demand register, bypassing the trajectory generator. This leads to a full acceleration, full speed move to the new target position and ignores maximum speed and maximum acceleration settings. Use this command with caution.

Usage: PO arg1
arg1 Description: Relative position offset
arg1 Data Type: Signed Integer
arg1 Range: spMin < Target Position < spMax

PC – Set PID Target to Current Position

Set the current position setpoint to the current absolute position value.

Usage: PC

LK – Lock or Unlock Serial Command-Line-Interface

Lock or unlock the serial command line interface.

Usage: LK arg1
arg1 Description: Command string
arg1 Data Type: String
arg1 Range: “lock”, “unlock”

FW – Show Firmware Installed on Active and Inactive Partitions

Show any firmware loaded onto the active and inactive flash memory partitions.

Usage: FW

SA – Swap Active Firmware Partition

Swap the active and inactive flash memory partitions. The CPU must be reset in order to run the new active partition.

Usage: SA arg1
arg1 Description: Passcode to execute command
arg1 Data Type: Unsigned Integer
arg1 Range: “321”

ZC – Run Actuator Calibration Utility

Run the actuator’s calibration utility. The actuator must be uncoupled from any mechanism or load and free to move through its entire mechanical stroke. If successful, the **ZC** command will overwrite certain configuration variables and save all of the configuration settings to non-volatile memory. The actuator must be restarted after this command is issued using the **ZR** command. Consult Ultra Motion engineering before issuing this command.

Usage: ZC arg1
arg1 Description: Passcode to execute command
arg1 Data Type: Unsigned Integer
arg1 Range: “321”

ZR – Reboot Actuator

Restart the actuator controller. Upon restart the actuator will load all configuration settings from non-volatile memory.

Usage: ZR arg1
arg1 Description: Passcode to execute command
arg1 Data Type: Unsigned Integer
arg1 Range: “321”

ZU – Run Serial Firmware Update Utility

The ZU command closes the serial CLI and runs the serial firmware update utility.

Usage: ZU arg1
arg1 Description: Passcode to execute command
arg1 Data Type: Unsigned Integer
arg1 Range: “321”

L-Series Configuration Variables

This section details configuration variables used by this firmware. These variables are stored within the controller's non-volatile memory and are configurable via the RS-485 serial interface. All configuration variables can be set with the **WV** command. For example, "wv opMode 1". To save all configuration variables to non-volatile memory, use the command "cw 321".

L-Series Configuration Variables Quick Reference Table

Variable	Description	Group	Default Value	Notes
opMode	Operating Mode Selector	Actuator Operation	0	Default: Serial CLI Mode
rPos	Retracted Hard Stop Position	Actuator Travel Limits	1024	Units: Encoder Counts
ePos	Extended Hard Stop Position	Actuator Travel Limits	rPos + Stroke	Units: Encoder Counts
spMin	Software Position Minimum	Actuator Travel Limits	rPos + 1024	Units: Encoder Counts
spMax	Software Position Maximum	Actuator Travel Limits	ePos - 1024	Units: Encoder Counts
maxCurr	Max Motor Current Demand	Motion Control	10000	
pkd	PID gain kd	Motion Control	1000.0	
pki	PID gain ki	Motion Control	0.2	
pkp	PID gain kp	Motion Control	300.0	
maxSpeed	Max Speed for Trajectory Moves	Motion Control	400000	
accel	Accel/Decel for Trajectory Moves	Motion Control	2000	
ovbOn	Overvoltage Dynamic Braking	Motion Control	1	Default: Enabled
CANspd	Can Bus Baud Rate Selector	CAN Bus	0	Default: 1 Mbps
CANext	Can Bus Message Type	CAN Bus	1	Default: Extended Message Type (29-bit ID)
rxID	CAN Position Command RX ID	CAN Mode Operation	0x00000003	
rxMask	Mask for CAN RX ID	CAN Mode Operation	0x1FFFFFFF	
rxData	Position Command Data Format	CAN Mode Operation	<>	Default: Position LSB, Position MSB
pMin	Minimum Position Command	CAN Mode Operation	0	
pMax	Maximum Position Command	CAN Mode Operation	65535	
inEna	Interpolation Enable Flag	CAN Mode Operation	1	Default: Enabled
canIvl	Interpolation Interval	CAN Mode Operation	50	Units: Milliseconds
canTO	Position Command Timeout	CAN Mode Operation	1250	Units: Milliseconds
cInvrt	Invert Response to CAN Command	CAN Mode Operation	0	Default: Does Not Invert
cSUact	Startup Action Selector	CAN Mode Operation	0	Default: Hold Position
cTOact	Timeout Action Selector	CAN Mode Operation	0	Default: Hold Last Position, Last Current Command
defPos	Default Position	CAN Mode Operation	(spMin + spMax)/2	Units: Encoder Counts
txEna	Telemetry Enable Flags	CAN Telemetry	0	Default: Disabled
tx1Data	Telemetry Data Format 1	CAN Telemetry	GKPCD	
tx1ID	Telemetry Message Destination ID 1	CAN Telemetry	0x0000007F	

Variable	Description	Group	Default Value	Notes
tx1Ivl	Telemetry Interval 1	CAN Telemetry	1000	Units: Milliseconds
tx2Data	Telemetry Data Format 2	CAN Telemetry	klmnpb	
tx2ID	Telemetry Message Destination ID 2	CAN Telemetry	0x000027F	
tx2Ivl	Telemetry Interval 2	CAN Telemetry	2500	Units: Milliseconds
tx3Data	Telemetry Data Format 3	CAN Telemetry	wxy	
tx3ID	Telemetry Message Destination ID 3	CAN Telemetry	0x000037F	
tx3Ivl	Telemetry Interval 3	CAN Telemetry	5000	Units: Milliseconds
evntID	Event Message Destination ID	CAN Event Messages	0x0000001F	
evntIvl	Event Message Min Interval	CAN Event Messages	4000	Units: Milliseconds
evntWrn	Warning Event Mask	CAN Event Messages	0x0000	
evntWrnC	Warning Event Mask - Clear on Broadcast	CAN Event Messages	0x3FFF	
evntMsc	Miscellaneous Event Mask	CAN Event Messages	0x0000	
IDbyte	Identification Byte	CAN Event Messages	255	
cliBaud	Serial Baud Rate	RS485 Serial CLI	115200	Units: Baud
cliLock	CLI Lock on Startup	RS485 Serial CLI	1	Default: Unlocked
cliBanr	Startup Banner	RS485 Serial CLI	1	Default: Enabled
tPos1	Trajectory Position 1	RS485 Serial CLI	3072	Units: Encoder Counts
tPos2	Trajectory Position 2	RS485 Serial CLI	4096	Units: Encoder Counts
posLe	Position Less than Threshold	Status Bits	0	Units: Encoder Counts
posGr	Position Greater than Threshold	Status Bits	50175	Units: Encoder Counts
stplvl	Stopped Speed Threshold	Status Bits	10	Units: Milliseconds @ 0 velocity count
ovCurr	Motor Current Threshold	Status Bits	8200	
ovTemp	Over Temperature Threshold	Status Bits	60.0	Units: Celsius
unTemp	Under Temperature Threshold	Status Bits	-30.0	Units: Celsius
ovHumi	Over Humidity Threshold	Status Bits	85.0	Units: Percent

Table 13: Configuration variable reference list

Note: Default values for rPos, ePos, spMin, spMax, and defPos are set during actuator calibration.

opMode – Operating Mode

This setting determines whether the actuator's motion is controlled by the RS-485 command line interface (opMode = 0), or by CAN bus command frames (opMode = 1)

Data Type: Integer
Valid Range: 0 to 1
Default: 0

rPos, ePos – Retracted Hardstop Position, Extended Hardstop Position

These two configuration variables define the position of the actuator's fully-retracted and fully-extended hardstops. By default, the rPos variable is set along with the zero position of the Phase Index absolute position sensor such that position 0 is 1 screw revolution beyond the actuator's retracted hardstop (rPos = 1024). The full mechanical stroke length of the actuator should be ePos – rPos. These variables usually should not be modified by the user except through the use of the built-in actuator calibration routine ("ZC 321" CLI command). The values are expressed in Phase Index encoder counts. There are 1024 Phase Index encoder counts per screw revolution in the L-Series actuator.

Data Type: Integer
Valid Range: 0 – 50175
Rules: rPos ≤ spMin < spMax ≤ ePos
Default: rPos = 1024, ePos = rPos + Stroke Length

spMin, spMax - Software Position Minimum, Software Position Maximum

These two configuration variables set the minimum and maximum allowable position command in the L-Series actuator. The values are expressed in Phase Index encoder counts.

Data Type: Integer
Valid Range: rPos to ePos, spMax >= spMin + 1
Rules: rPos ≤ spMin < spMax ≤ ePos
Default: spMin = rPos + 1024, spMax = ePos – 1024

cliBaud – Serial Baud Rate

This setting sets the Baud rate for serial communication. Serial is accessible in all control modes and is used for diagnostics, configuration, initial setup, and control with opMode = 0. Default Baud rate is 115200. Lower baud rates will be more tolerant to noise and crosstalk at the expense of data bandwidth.

Data Type: Integer
Valid Range: 4800 to 460800
Default: 115200

cliLock – Command Line Interface Lock

This setting determines if the CLI will startup locked or unlocked. A setting of 1 is unlocked on startup.

Data Type: Integer
Valid Range: 0 to 1
Default: 1

cliBanr – CLI Power-On Banner

This setting determines if the serial banner that includes the actuator's firmware and hardware revisions, serial number, etc. is transmitted on reset or power-cycle. A setting of 0 disables the banner on startup.

Data Type: Integer
Valid Range: 0 to 1
Default: 1

pkp, pki, and pkd – PID Gains k_p, k_i, and k_d (Respectively)

These three values represent the gains for the proportional, integral, and derivative terms of the position PID control loop. Internal scaling of these gains is unique to this PID algorithm. Default factory values used represent typical stable gains. Adjusting these values is not recommended unless first discussed with Ultra Motion engineering.

Data Type: Float
Valid Range: -
Default: pkp = 300.0, pki =0.200, pkd = 1000.0

maxCurr - Max Motor Current Demand

This setting limits the motor current demand signal that commands the current loop, thereby limiting the force produced by the L-Series. The value represents a percentage of full current output where 32767 equals 100%. The relationship is linear with a slight offset do to unloaded running friction of the system. Contact Ultra Motion engineering for more detailed information. Care must be taken if exceeding the continuous load rating of the actuator or if there's a potential to drive into a hardstop.

Note that setting maxCurr low does not lead to a freely backdriveable actuator with the L-Series and will instead cause a dynamic braking behavior. The actuator's enable input must be de-energized or the CAN startup/timeout action set to COAST the motor in order to have the actuator backdrive freely.

Data Type: Integer
Valid Range: 0 to 32767
Default value: 10000 (approximate continuous limit at 25°C with natural convection)

maxSpeed - Maximum Speed

This variable sets the top speed for trapezoidal profile trajectory moves. Note that it is possible to set maxSpeed higher than the maximum physical speed capability of the actuator. This can lead to control instability. The maximum speed that the actuator can achieve depends on the operating voltage, load, gear reduction, and other factors. Exceeding the maximum physical speed with the trajectory generator can result in integral windup, target position overshoot, and deviation from the defined trajectory profile.

Data Type: Integer
Valid Range: 1 to 10000000
Default: 400000

accel - Acceleration and Deceleration Rate

This setting defines the acceleration and deceleration the L-Series will use in profile trajectory moves. Note: the acceleration and deceleration will be equal. Setting the acceleration value greater than what's physically achievable by the actuator for a given maxCurr setting and load can lead to control loop instability.

Data Type: Integer
Valid Range: 0 to 131071
Default: 2000

ovbOn – Overvoltage Dynamic Braking

When set to 1 value, the actuator will dynamically brake when the sensed bridge voltage is greater than 55.0 VDC and will disable dynamic braking when the sensed voltage drops below 52.0 VDC. This helps to prevent the actuator's regenerated energy from spiking the bridge voltage to levels that can damage the actuator.

Setting this value to zero disables this dynamic braking functionality and should only be done if the power supply is capable of handling the regenerated energy from a backdriving or deceleration event, or if power shunt electronics are used to prevent the bus voltage from spiking to an unsafe level.

Data Type: Integer
Valid Range: 0 to 1
Default: 1

CANspd – CAN Bus Baud Rate

This variable defines the baud rate of the CAN interface. There are 8 options designated by the integers 0 to 7.
0 = 1 Mbps, 1 = 500 Kbps, 2 = 250 Kbps, 3 = 125 Kbps, 4 = 100 Kbps, 5 = 50 Kbps, 6 = 20 Kbps, 7 = 10 Kbps

Data Type: Integer
Valid Range: 0 to 7
Default: 0

CANext – CAN Bus Message Type

This variable defines whether the L-Series is configured for CAN 2.0B standard message type (11-bit identifiers), or extended message type (29-bit identifiers). CANext = 0 configures standard message type (11-bit ID). A value of 1 in CANext sets the actuator to extended message type (29-bit ID).

Data Type: Integer
Valid Range: 0 to 1
Default: 1

rxID – CAN RX Identifier

rxID is the actuator's network address and is used along with rxMask to filter incoming CAN command messages. For acceptance, the message's identifier must match rxID where each corresponding bit in rxMask is set to '1'. If CANext = 0, only the lower 11 bits of rxID and rxMask are examined (standard message type). If CANext is 1, the lower 29 bits of rxID and rxMask are examined (extended message type).

Data Type: Integer
Valid Range: 0x00000000 to 0x1FFFFFFF
Default: 0x00000003

rxMask –Mask for CAN RX Identifier

rxMask is used along with rxID to filter incoming CAN command messages. For acceptance, the message's identifier must match rxID where each corresponding bit in rxMask is set to '1'. If a bit in rxMask is set to '0', the corresponding bit of an incoming can message is matched for acceptance regardless of its value. If rxMask is set to 0x00000000, CAN messages with any identifier will be accepted. If rxMask is set to 0x1FFFFFFF, only CAN messages with an identifier that exactly matches the relevant bits of rxID will be accepted. If CANext = 0, only the lower 11 bits of rxID and rxMask are examined (standard message type). If CANext is 1, the lower 29 bits of rxID and rxMask are examined (extended message type).

Data Type: Integer
Valid Range: 0 to 0x1FFFFFFF
Default: 0x1FFFFFFF

rxData – CAN Command Frame Data Format

This variable configures the data format of received position command messages. rxData is a string with a length from 1 to 8 characters. Each character in rxData designates a function for the corresponding data byte in the command message frame. The number of data bytes in the command message frame must match the number of characters in rxData. For example, if the master is sending out command messages with 8 data bytes, then rxData should be padded with 'X' or 'x' like this: "xxxx<>xx", where '<' is the position low byte, '>' is the position high byte, and 'x' means ignore this byte. The characters '(' and ')' can also be used to set the max motor current demand. '(' is max current demand low byte, and ')' is max current demand high byte. The acceptable range for the position command value is pMin to pMax. The acceptable range of the max current demand value is 0 to 32,767. The max current demand value is not updated if '(' and ')' characters are not included in rxData.

Data Type: String
Valid Range: <>()Xx
Default: <>

cSUact – CAN Startup Action

This variable defines the behavior of the actuator after start-up and before receiving a valid CAN position command message.

cSUact = 0 holds the current position
cSUact = 1 executes a trajectory move to the default position defPos
cSUact = 2 COAST the motor
cSUact = 3 Dynamic brake the motor

Data Type: Integer
Valid Range: 0 to 3
Default: 0

cTOact – CAN Timeout Action

This variable defines the behavior of the actuator after not receiving a valid CAN position command message within the timeout period (canTO ms). The actuator must receive at least 1 valid CAN position command message before a timeout can occur.

cTOact = 0 Holds the last valid position with the last valid max motor current demand value
cTOact = 1 Starts a trajectory move to the default position defPos with the last valid max current demand value
cTOact = 2 COAST the motor
cTOact = 3 Dynamic brake the motor
cTOact = 4 Holds the last valid position with the configured maxCurr setting
cTOact = 5 Executes a trajectory move to the default position defPos with the configured maxCurr setting

Data Type: Integer
Valid Range: 0 to 5
Default: 0

canTO – CAN Position Command Timeout Period

This variable defines the CAN position command message timeout period in increments of 1 ms.

Data Type: Integer
Valid Range: 0 to 65535
Default: 1250

pMin, pMax – CAN Position Command Range

This variable defines the valid command range that will be sent to the actuator via CAN messages. The value of pMin/pMax will be mapped to the actuator's travel range spMin/spMax. If cInvrt is set to 1, pMax will map to spMin, and pMin will map to spMax.

Data Type: Integer
Valid Range: 0 to 65535
Default: pMin = 0, pMax = 65535

cInvrt – Inversion of Response to CAN command

Inverts the response of the actuator with respect to the CAN position command. A value of 0 does not invert. A value of 1 inverts.

Data Type: Integer
Valid Range: 0 to 1
Default: 0

defPos – Default Position

defPos is the absolute encoder value of the default position. The actuator can move to defPos upon startup if no valid position command messages have been received, or in the event of a position command message not being received in the canTO timeout period. The behavior of the actuator in these situations is defined by the cSUact and cTOact variables.

Data Type: Integer
Valid Range: spMin to spMax
Default: (spMin + spMax)/2

canIvl –Interpolation Interval

This variable defines the interpolation period in units of 1 ms for the received CAN commands. The default value is 50 (50 milliseconds), which is equivalent to a 20 Hz position update rate.

Data Type: Integer
Valid Range: 1 to 65535
Default: 50

inEna –Interpolation Enable Flag

Setting inEna to 0 disables position interpolation, setting inEna to 1 enables position interpolation.

Data Type: Integer
Valid Range: 0 to 1
Default: 1

txEna – Telemetry Enable Flags

Setting txEna to 0 disables all telemetry messages from the actuator. Setting to a value from 1 to 7 (0b001 to 0b111) will activate the corresponding telemetry message. For example, txEna=3 (0b011) would enable the broadcasting of tx1Data and tx2Data

Data Type: Integer
Valid Range: 0 to 7
Default: 0

txNID – CAN Telemetry Message ID

These variables are the 29-bit or 11-bit CAN 2.0B identifiers for the telemetry messages. They represent the destination address of each telemetry message. If CANext=0, only the lower 11 bits are used.

Data Type: Integer
Valid Range: 0 to 0x1FFFFFFF
Default: tx1ID = 0x0000007F, tx2ID = 0x000027F, tx3ID = 0x000037F

txNData – Telemetry Data Selection

The specific telemetry data bytes to be broadcast are selected with these configuration variables. The string may have a length from 1 to 8 characters. Each character in txNData designates one variable in the telemetry message. Variables may be one or more bytes in length each. The total number of data bytes cannot exceed 8 for a CAN 2.0B telemetry message.

Data Type: String
Valid Range: A-Z, a-z, 3, 4, 6, 7, 8, 9
Default: tx1Data = GKPCD, tx2Data = klmnbp, tx3Data = wxy

txNIvl – Telemetry Interval

The telemetry intervals define the broadcast period of each telemetry message from the actuator in milliseconds. Care must be taken to ensure the CAN bus is not overloaded by too rapid a transmission rate.

Data Type: Integer
Valid Range: 2 to 10000
Default: tx1Ivl = 1000, tx2Ivl = 2500, tx3Ivl = 5000

ovCurr – Motor Current Threshold

Defines the motor current threshold that causes the "Over Current" status bit to go high (when Motor Current > ovCurr). This variable is only used to define the behavior of the related status bit.

Data Type: Integer
Valid Range: 0 to 32766
Default: 8200

stpIvl – Stopped Speed Threshold

Defines the number of milliseconds with a 0 velocity count before the actuator is considered to be "stopped" and the "stopped" status bit is set high. This variable is only used to define the behavior of the related status bit.

Data Type: Integer
Valid Range: 1 to 65535
Default 10

ovTemp – Over Temperature Threshold

Defines the temperature threshold that causes the "Over Temperature" status bit to go active (when Temp > ovTemp). This variable is only used to define the behavior of the related status bit. Units are in °C

Data Type: Float
Valid Range: -50.0 to 149.0
Default: 60.0

unTemp – Under Temperature Threshold

Defines the temperature threshold that causes the "Under Temperature" status bit to go active (when Temp < unTemp). This variable is only used to define the behavior of the related status bit. Units are in °C

Data Type: Float
Valid Range: -49.0 to 150.0
Default: -30.0

ovHumi – Over Humidity Threshold

Defines the relative humidity threshold that causes the "Over Humidity" status bit to go active (when RH > ovHumi). This variable is only used to define the behavior of the related status bit. Units are in %

Data Type: Float
Valid Range: 0 to 100.0
Default: 85.0

tPos1 – Trajectory Position 1

Default position that can be used to command trajectory moves "T1"

Data Type: Integer
Valid Range: spMin to spMax
Default: 3072

tPos2 – Trajectory Position 2

Default position that can be used to command trajectory moves “T2”

Data Type: Integer
Valid Range: spMin to spMax
Default: 4096

posLe – Position less than threshold

Used as an additional position threshold that controls the posLe status bit. The status bit will go high if absolute position is less than the posLe threshold. This variable is only used to define the behavior of the related status bit.

Data Type: Integer
Valid Range: 0 to 50175
Default: 0

posGr – Position greater than threshold

Used as an additional position threshold that controls the posGr status bit. The status bit will go high if absolute position is greater than the posGr threshold. This variable is only used to define the behavior of the related status bit.

Data Type: Integer
Valid Range: 0 to 50175
Default: 50175

evntID – Event ID

This is the CAN ID that will be used for asynchronous event messages. If CANext=0, only the lower 11 bits are used.

Data Type: Integer
Valid Range: 0 to 0x1FFFFFFF
Default: 0x0000001F

evntMsc– Miscellaneous Event Mask

Bit mask for miscellaneous event enable

Data Type: Integer
Valid Range: 0 to 65535
Default: 0x0000

evntWrn– Warning Event Mask

Bit mask for warning event enable

Data Type: Integer
Valid Range: 0 to 16383
Default: 0x0000

evntWrnC– Warning Event Mask – Clear on Broadcast

Bit mask for warning bit is cleared on event message broadcast.

Data Type: Integer
Valid Range: 0 to 16383
Default: 0x3FFF

evntIvl – Minimum Event Message Interval

The minimum delay between successive warning event messages for the same warning bit in milliseconds.

Data Type: Integer
Valid Range: 100 to 65535
Default: 4000

IDbyte – Identification Byte

An 8-bit value that can be used to identify actuators on the CAN bus. The byte is used in asynchronous event messages and can be added to telemetry messages. This can be useful for identification if multiple actuators are sending messages to a single address.

Data Type: Integer
Valid Range: 0 to 255
Default: 255

Design Guidelines

Below are some common pitfalls and guidelines to consider when using our linear servo actuators. Contact Ultra Motion engineering for advice regarding the successful integration of the L-Series into an application.

Never "Side-Load" an Actuator Not Rated for Side-Load

Rod-style linear actuators such as the L-Series are typically not rated for bending moments, loads perpendicular to the output shaft axis, or any force loads other than axial tension or compression. Significant "side-loads" often occur inadvertently with over-constrained actuator mounting. Side-loads result in accelerated wear, reduced performance, or failure of the actuator. Mounting methods must be designed with adequate rotational degrees of freedom, such as pivoting joints (like a clevis or trunnion), or spherical bearings on both ends of the actuator, to ensure the actuator is only loaded in the axial direction when accounting for assembly motion and tolerances in your structure.

Beware Running an Actuator into a Hard-Stop

When using an actuator with a BLDC motor, take care that you do not run the actuator into a physical "hard-stop", such as a machine element or any physical body which the actuator impacts on its travel and which disallows movement. If this happens, the control system will attempt to obey position commands by powering through the physical block, capping the motor current command to the maximum. Often, this results in the motor over-heating and burning out, especially with higher maximum motor current settings.

The exact continuous limit is difficult to accurately predict due to the unique heat transfer environments from application to application. A maxCurr setting of 10,000 is a rough approximation of the continuous capability of the actuator assuming a 25°C ambient environment and natural convection.

Regenerative Energy

The actuator can push regenerated energy back into the power supply during deceleration or backdriving events. The power supply being used in the application must be sized adequately to prevent unwanted bus spikes during use. Regulated power supplies are particularly susceptible to bus spikes due to regenerated energy. Consider adding shunt electronics to the power system if significant amounts of regenerative energy are expected, a regulated power supply is being used, or if the bus is shared with other sensitive electronics.

Solid Particle and Liquid Exposure

The L-Series makes use of a high durometer shaft scraper, spring energized PTFE shaft seal, and O-ring seals on all static mechanical joints in order to provide robust IP67 sealing. Care should be taken to avoid the ingress of solid particles into an unmated connector by always using a connector cap when unmated.

Unit Conversions

Definitions

Variable	Definition	Units	Note
N	Sensor Counts	$-$	N denotes sensor counts for the specific data type in question
P	Position	in	Linear Position with respect to retracted endstop (rPos) of the actuator. The retracted endstop is always at $N = 1024$.
L	Screw Lead	in	The lead of the drive screw
a	Acceleration	in/s^2	Linear acceleration, which is always positive (scalar) for setting 'accel'
v	Velocity	in/s	Linear velocity of the actuator shaft
V_{bus}	Bus Voltage	V	Supply voltage to the actuator (before bridge enable switch)
V_{bridge}	Voltage at Bridge	V	Voltage at the bridge driver (after bridge enable switch)
T	Temperature	$°C$	Internal temperature, as measured at the controller PCB
H_R	Relative Humidity	$\%$	Relative humidity, actual values will be between 0 and 100%
I_{motor}	Motor Current	A	Current through the BLDC motor
I_{bridge}	Bridge Current	A	Current through the bridge enable switch

Table 14: Unit conversion definitions

Equations

Variable	Conversion to physical units
Position	$P = \frac{(N - 1024)L}{1024}$
Speed	$v = maxSpeed * 1000 * \frac{L}{65535 * 1024}$
Accel	$a = accel * 1000^2 * \frac{L}{65535 * 1024}$
Bus Voltage	$V_{bus} = VinSenADC * \frac{55.0}{16380}$
Bridge Voltage	$V_{bridge} = VinSenADC * \frac{55.0}{16380}$
Motor Current	$I_{motor} = motorCurrent * \frac{20.0}{32752}$
Bridge Current	$I_{bridge} = ibrSenADC * \frac{30}{16380}$
8-bit Temperature	$Temperature\ (°C) = Feedback - 50$

Table 15: Unit conversion equations

Contact Information

If you have any questions about the L-Series or any of our other products, contact us by one of the following methods:

INQUIRY

Leave a web inquiry (to be replied to within one business day):
ultramotion.com/contact

LIVE CHAT

Live Chat directly with one of our engineers:
ultramotion.com

EMAIL

Email (to be replied to within one business day):
info@ultramotion.com

CALL

PH: 888-321-9178, 631-298-9179
Fax: 631-298-6593

ADDRESS

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HOURS

Our Business Hours:
Monday-Friday
9AM – 5PM EST