.Application Note - LA12 / LA12F Product Families

1. Introduction

This document includes information to support the correct driving and control of the following Product families:

- LA12
- LA12F

The LA12 / LA12F prototyping kits contain:

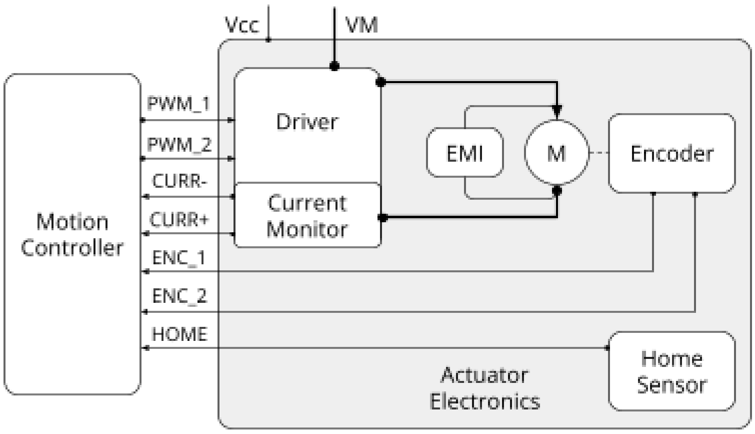
- A LA12 / LA12F linear actuator with tip fitted,
- A 14-pin, 1mm pitch FPC cable,
- A break-out PCBA.

The actuator PCBA is equipped with the following features:

- H-bridge motor driver,
- Rotary incremental encoder,
- Current monitor,

- Home sensor

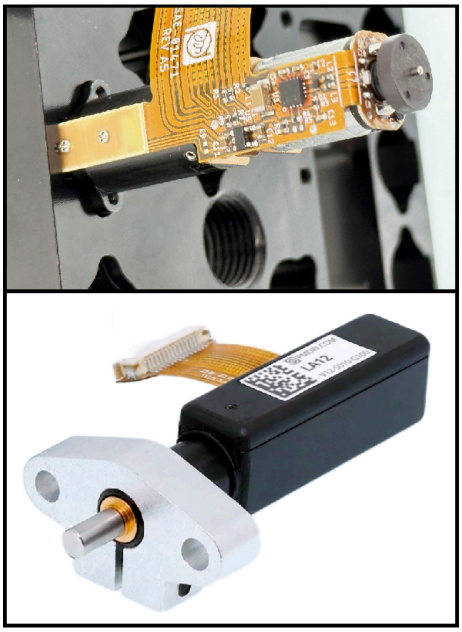
The actuator block diagram can be found below. The driver is the MAX 22201.



2. Quick Start Guide

2.1. Mechanical mounting

The LA12, and LAF12 models have different mounting methods. The actuators can be mounted either:



- Using the mounting "ears" and 2x M2 screws (LAF12 range).

- Using a 10mm bracket (LA12 range) - this is commonly found in XY micrometer tables - taking care not to over-tighten on the actuator housing so that the housing doesn't deform. We also offer the mounting hardware brackets as shown on the product pages and datasheets

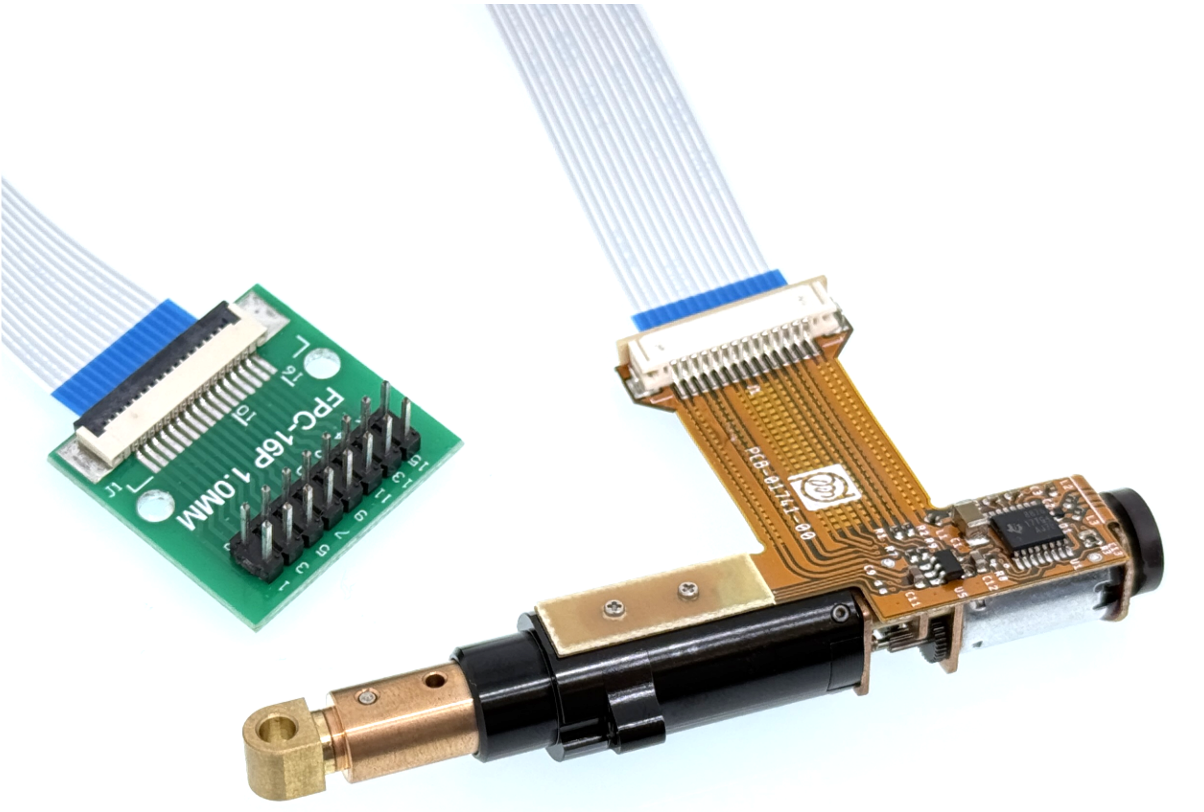
2.2. Electrical connections

The linear actuator requires 2 power supply sources:

- A 3.3-5V power source (Vcc) for the driver and sensors,

- Depending on the actuator, a 6-18V power source (VM) for the motor supply (this voltage should not exceed the actuator rating).

The actuators are fitted with Molex connector p/n 0522711479. A suitable FFC cable (1mm pitch 14 pin) and break-out board are included in the development kit.



Steps to make electrical connections:

1. Connect FPC cable to the actuator,
2. Connect FPC cable to break-out board,
3. Connect sensors power source plus and ground terminals to break-out board 5V (pin 14) and GNDIO (pin 8) respectively (⚠ **take care not to reverse polarity - there is no protection** ⚠),
4. Connect motor power source plus and ground terminals to break-out board 18VDC (pin 1) and GND (pin 2) respectively (⚠ **take care not to reverse polarity - there is no protection** ⚠),
5. Combine the grounds of the sensors power source and motor power source by connecting break-out board GNDIO (pin 6) and GND (pin 10),

6. Connect PWM_1 (pin 11) and PWM_2 (pin 12) to digital output pins of the controller / host microcontroller (MCU),
7. Connect HOME (pin 5), ENC_1 (pin 7) and ENC_2 (pin 9) to digital input pins of the controller / host MCU if desired,
8. Connect CURR+ (pin 4) and CURR- (pin 3) to analogue input pins of the controller / host MCU if desired.

Connector pinout			
1	VM	Power	Positive power supply for the motor. ⚠ **Do not exceed rated voltage.** ⚠
2	GND	Power	Ground supply for the motor.
3	CURR-	Analogue	Current measurement - negative differential output
4	CURR+	Analogue	Current measurement - positive differential output
5	HOME	Digital	LOW when the actuator has reached the HOME (fully retracted) position
6	GNDIO	Power	Ground supply for the hall sensors and encoder
7	ENC_1	Digital	A/B encoder signal #1
8	GNDIO	Power	Ground supply for the hall sensors and encoder
9	ENC_2	Digital	A/B encoder signal #2
10	GND	Power	Ground supply for the motor.
11	PWM_1	Digital	Pulse width drive signal #1
12	PWM_2	Digital	Pulse width drive signal #2
13	GND	Power	Ground supply for the motor.
14	5V	Power	Positive power supply for the hall sensors and encoder. ⚠ **Do not exceed rated voltage.** ⚠

2.3. Recommended Power-up Sequence

Following the power-up sequence below minimizes the risk of unwanted actuator movement due to undefined driving signals or delays between pin initializations.

1. Sensors power line,

2. Initiate PWM signals either both LOW (“fast decay” mode) or both HIGH (“slow decay” mode) - ref. Actuator Driving section for details,
3. Motor power line.

3. Actuator Driving

The actuator can be run at full speed by applying DC voltages to the PWM_1 and PWM_2 pins; or speed controlled by applying pulse width modulation (PWM) to those pins.

A frequency in the order of 20 kHz is typically used:

- A lower frequency may cause audible noise,
- A much higher frequency (50 kHz or more) may result in lower electrical efficiency and reduced lifetime

Actuator truth table:

PWM_1	PWM_2	Description
0	0	Coast (driver H-bridge Hi-Z)
0	1	Retract
1	0	Extend
1	1	Brake (low-side slow decay)

The actuator can be driven in 2 “modes”:

- “Fast decay” mode
- “Slow decay” mode

In “fast decay” mode, during the off-time of PWM cycles, the opposing mosfets are energized, and current is allowed to flow back to the power supply, causing it to rapidly decay to zero.

In “slow decay” mode, during the off-time of PWM cycles, both low-side mosfets are energized and both motor terminals are connected to the ground. Current then decays in line with the winding’s LR time constant.

Both modes have advantages and drawbacks - “slow decay” is often preferred due to the lower current ripple and more linear motor response.

Note that the actuator speed varies with load.

- At a given load, PWM duty is almost directly proportional to actuator speed,
- At a given PWM duty, speed varies almost linearly with load.

As noted above, the actuator response is more linear in “slow decay” mode.

3.1. Driving the actuator in “slow decay” mode

To drive the actuator in “slow decay” mode:

- On MCU initiation, set both PWM_1 and PWM_2 pins HIGH (actuator will be stopped),
- To move the actuator in the “extend” direction, keep PWM_1 signal HIGH, and apply either a DC or pulse width modulated signal to pin PWM_2. Actuator speed is inversely proportional to PWM duty e.g.
    - 100% duty (pin HIGH) corresponds to “0% speed” - stopped actuator,
    - 0% duty (pin LOW) corresponds to “100% speed” - actuator running at full speed,
    - 40% duty corresponds to “60% speed”.
- To move the actuator in the “retract” direction, keep PWM_2 signal HIGH, and apply either a DC or pulse width modulated signal to pin PWM_1. Actuator speed is inversely proportional to PWM duty.

3.2. Driving the actuator in “fast decay” mode

To drive the actuator in “fast decay” mode:

- On MCU initiation, set both PWM_1 and PWM_2 pins LOW (actuator will be stopped),
- To move the actuator in the “extend” direction, keep PWM_1 signal LOW, and apply either a DC or pulse width modulated signal to pin PWM_2. Actuator speed is somewhat proportional to PWM duty e.g.
    - 0% duty (pin LOW) corresponds to “0% speed” - stopped actuator,

- 100% duty (pin HIGH) corresponds to “100% speed” - actuator running at full speed,
- 60% duty corresponds to approximately “60% speed”.

- To move the actuator in the “retract” direction, keep PWM_2 signal LOW, and apply either a DC or pulse width modulated signal to pin PWM_1. Actuator speed is somewhat proportional to PWM duty.

4. Features Detailed Description

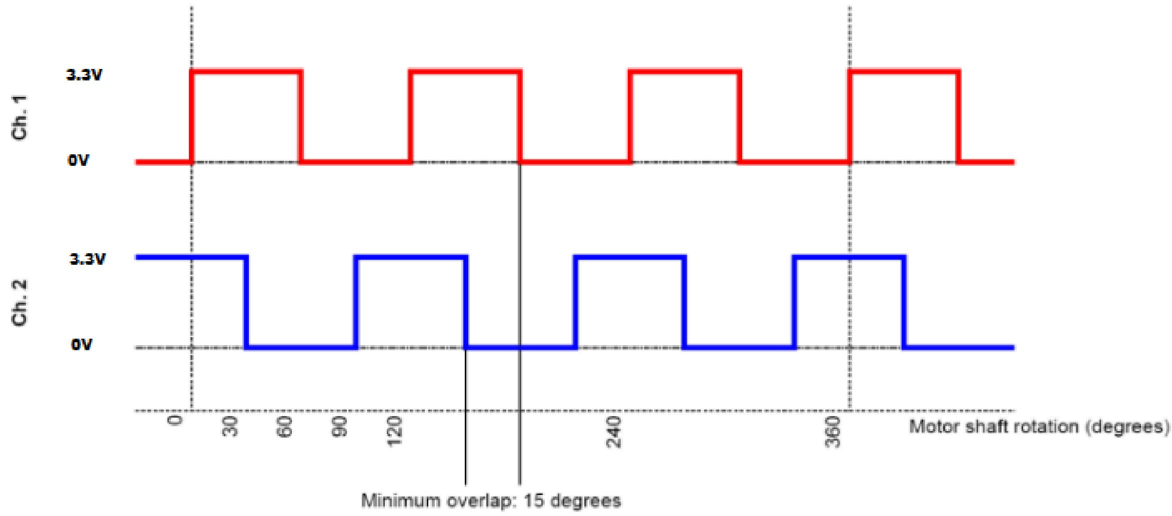
4.1. Home Sensor

The actuator is built with a hall effect magnetic home sensor to prevent the actuator from hitting an end-stop and locking at the retracted position. Ignoring the home sensor signal can result in an irrecoverable failure.

The output of the sensor switches LOW when the actuator reaches the home position. The sensor has hysteresis built in for stability. The home position is a safe distance from the end-stop.

4.2. Rotary Incremental Encoder

The actuator uses a rotary incremental encoder. This uses a two-channel hall sensor encoder which produces 12 counts per motor revolution (before gearbox). This creates a quadrature output signal on pins 7 and 9, with channel 1 leading channel 2 in the extending direction. The quadrature output signal in the retracting direction (channel 2 leading) is illustrated below.



The encoder resolution, counts from HOME to full extension, and direction for different gear ratios and strokes are summarized below.

Gearing option	Exact ratio	Exact resolution	Approx. resolution	Stroke option	Counts from HOME to full extend
-	-	µm / count	µm / count	-	Counts
010	629 / 65	8,125 / 1,887	4.3058	010	2,323
				030	6,968
				050	11,613
030	9,576 / 325	40,625 / 28,728	1.4141	010	7,072
				030	21,215
				050	35.358
100	83,657 / 845	105,625 / 250,971	0.4209	010	23,761
				030	71,282
				050	118,803

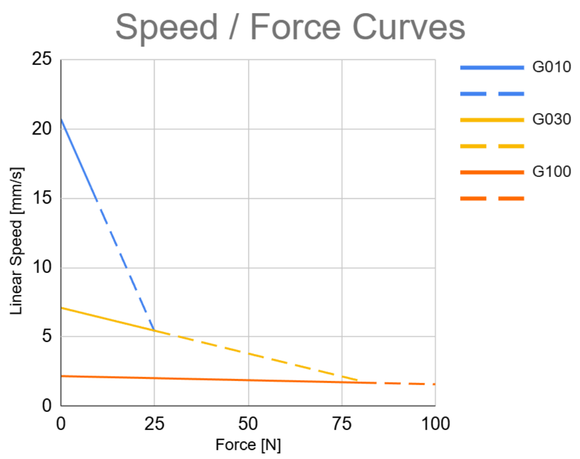
4.3. Current Monitor

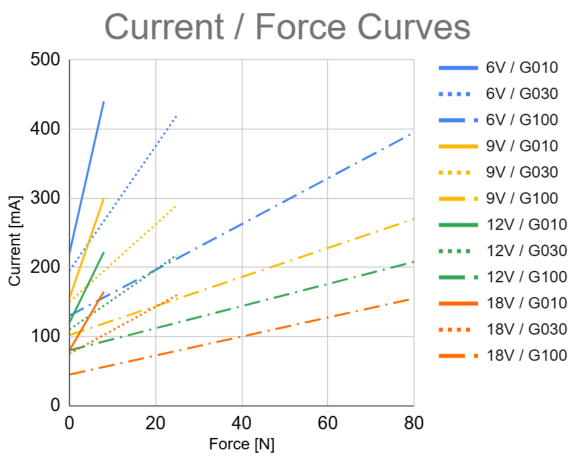
CURR+ (pin 4) and CURR- (pin 3) of the actuator provide a differential signal which outputs the current signal from the driver. The current can be calculated by measuring the voltage between pins 4 and 3 and applying a factor of 1 mA / mV e.g. a voltage output of 50mV corresponds to a motor current of 50mA.

This differential signal can be used to control the current through the motor and avoid damaging it; or to control the amount of force applied by the actuator.

4.4. Typical Performance

Speed / force and current / force curves for different voltage, stroke and gearing options can be found below.





5. Implementation recommendation

5.1. Limit of extension

Going beyond the actuator's stroke (the extension as measured from HOME) risks hitting the fully extended end-stop, and potentially locking the actuator in that position or permanently damaging it. The encoder count can be used to manage this.

5.2. Finding "Home" sequence

It is good practice to follow a repeatable homing sequence every time the actuator is retracted to protect against any loss of counts by the encoder over time. Such a sequence can also remove any backlash in the positioning. The best approach depends on the application - a typical sequence consists of

1. Retracting the actuator,
2. Stopping the actuator when the Home sensor switches to LOW,
3. Slowly extending the actuator,

4. Zeroing the encoder / position counter when the Home sensor switches to HIGH - using an interrupt increases accuracy,
5. Stopping the actuator.

We can suggest a sequence for your application if needed.

6. Contact and support information

Our friendly and knowledgeable application engineers can be reached by the following:

- Email: support@precisionmicrodrives.com
- Phone: +44 1932 252 482 - 9am ~ 6pm UK time.

7. Other Linear actuator technologies

We customise our linear actuators for production customers, and can offer miniature stepper and brushless motors, as well as swapping the spur gearbox for a planetary one. These changes are primarily made to enhance the longevity, or to meet electromagnetic or arc / spark / naked flame environment requirements.