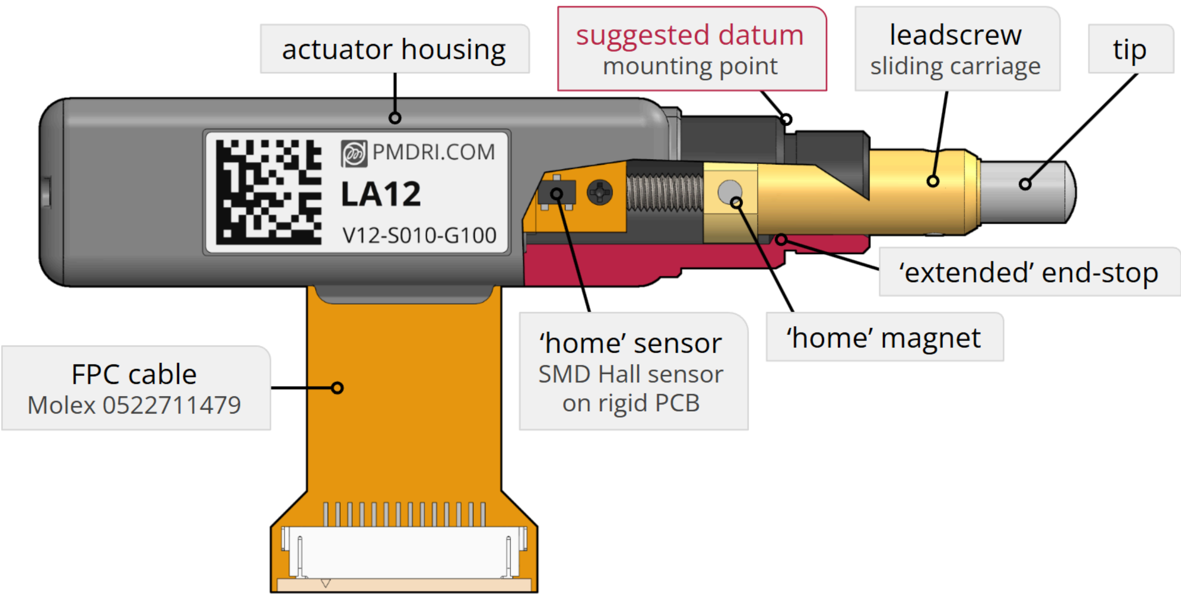
Home Position Explanation - LA12 / LA12F Product Families

1. Introduction

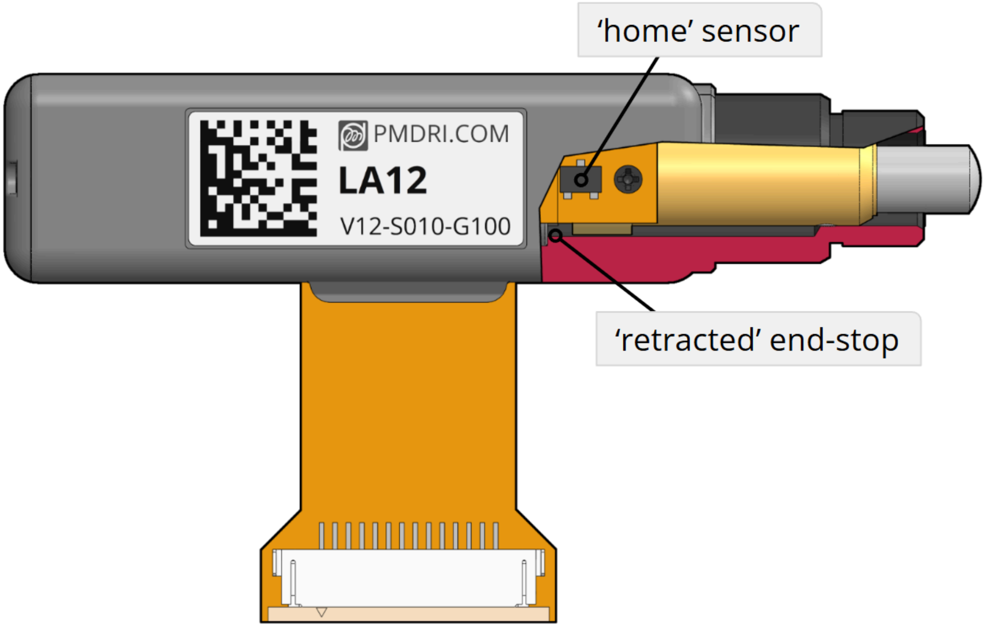
The diagram below shows a simplified layout of our standard linear actuator.



Linear actuators from Precision Microdrives, are fitted with a 'home' sensor. This sensor is a Hall effect switch that is activated by a neodymium magnet built into the leadscrew sliding carriage. It's this carriage which turns the rotation motion of the internal lead screw (driven by the geared motor), into the desired linear motion.

When the neodymium magnet comes into range of the hall sensor, the output of the hall sensor is switched from HIGH (undefined position), to LOW (the HOME position).

The HOME position Hall sensor is designed to be a short distance away from the 'retracted' end-stop.



This means that, when retracting the actuator back to the HOME position from an extended position, if power to the motor is cut when the hall sensor goes LOW, you can be confident that the motor (even with some inertial momentum) will not run the leadscrew sliding carriage, into the retracted end-stop of the actuator housing.

You *can* also use this HOME position as a datum point, **but** it cannot be guaranteed that the HOME position will be in dimensionally the exact same mechanical place, across a batch of actuators. This is due to variations in manufacturing tolerances, leadscrew backlash, magnet strength, and Hall sensor hysteresis between identical looking and specced actuators.

However, there *is* a technique that you can adopt, and this application note explains this. You can use it within your application to achieve a consistent and reliable datum across a field of actuators.

2. The risk around end-stops

The primary purpose of the home position sensor is a safety measure - it's an internal end-stop limit sensor for actuator retraction.

The output of the motor gearbox is attached to a lead screw which rotates to push / pull a sliding carriage, thereby creating linear motion in the tip, that interfaces the linear actuator to your application.

There's nothing to stop you from driving the sliding carriage up against the 'retracted' or 'extended' physical end-stops, created by the actuator housing.

When the sliding carriage is driven into this physical end-stop, it immediately stops, but the geared motor driving it doesn't. Even if you sense an increase in motor current and kill the drive signals to the motor instantly, the motor rotor will itself continue to turn with inertial momentum. This is amplified by the gearbox until the motor comes to rest, and through the leadscrew the sliding carriage will be pressed forcibly into the end-stop.

At this point the threads on the leadscrew and carriage will start to deflect based on how fast the motor was running before the carriage stopped. At slow speeds - i.e. a gentle actuation, the deflection won't be much and the actuator can be 'reversed out' of the end-stop with a bit more power. At high speeds - leading to a very rapid deceleration, it's possible for the actuator to become permanently stuck through thread deformation. That is to say, that under its own power, the actuator will not be able to 'reverse out' and away from the end-stop, because the torque requirement to turn the leadscrew will be too high.

Therefore in your application you must avoid driving the actuator into an internal end-stop, particularly at high speeds.

3. External loads

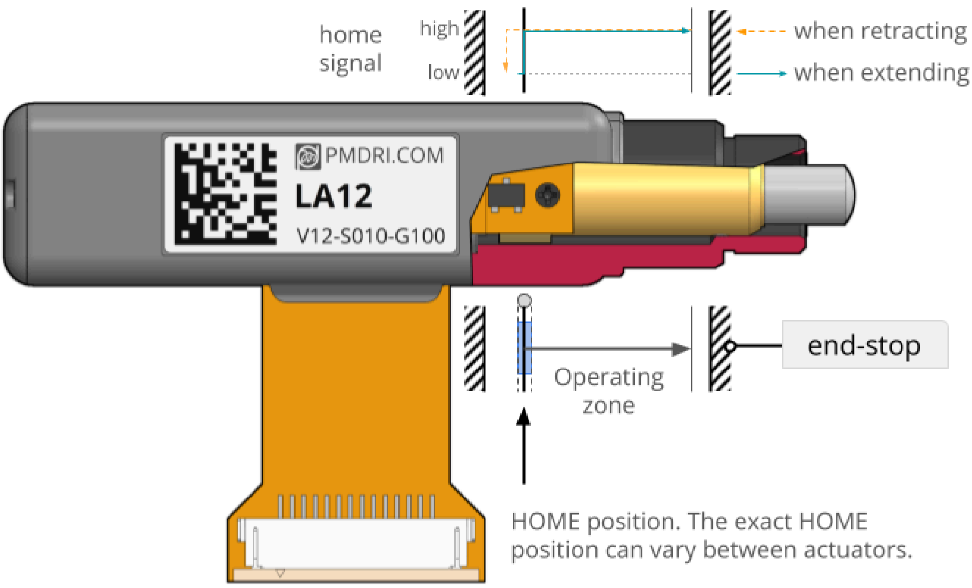
A similar problem might exist with an external load if the actuator was driven rapidly into an immovable object. Therefore caution is also required.

The linear actuators can press up against and move or hold a firm object - that is their purpose - observing the rated load (e.g. 50N) of course. But driving a linear actuator at a high velocity into any kind of immovable object can create momentary forces that far far exceed the rated load.

To avoid this, a combination of movement algorithms, and the home sensor should be used together.

4. To start, go home...

A good way to start is to check the home sensor. If LOW, you're already in the HOME position. Don't reverse the actuator any more. Instead drive slowly forwards until the home sensor goes HIGH, then stop. This is the 'extended' boundary of the HOME position, and what we consider the 'home datum'. You can reliably use this, as a datum point, for this specific actuator.



Bear in mind that if you drive to the 'extended' boundary of the HOME position too fast you may overshoot to a different datum, than if you made the same movement at a lower speed.

Next, use the encoder (or in the case of brushless linear actuators commutation hall sensor signals), to count the number of motor rotations, and if you haven't lost count or missed signals, you can always reliably calculate how far the actuator carriage is from the HOME datum. Since you know the length of travel available in that actuator model, you can build a virtual 'extended' boundary position into your control software, that is safely away from the 'extended' end-stop. We call this safe range the 'operating zone', and it's the useable range specified in the datasheet.

If, when you check, the home sensor is HIGH, you need to retract backwards until you reach the HOME position. We suggest doing this as slowly as possible (you can check the encoder / commutation hall sensors to know that the motor is turning), and then stop when the home sensor goes LOW.

5. Brownout, or you lost count?

In the case of power loss to the application, even if the encoder count is regularly saved to non-volatile memory, the actuator may be moving when power is lost, and through momentum will coast to a stop.

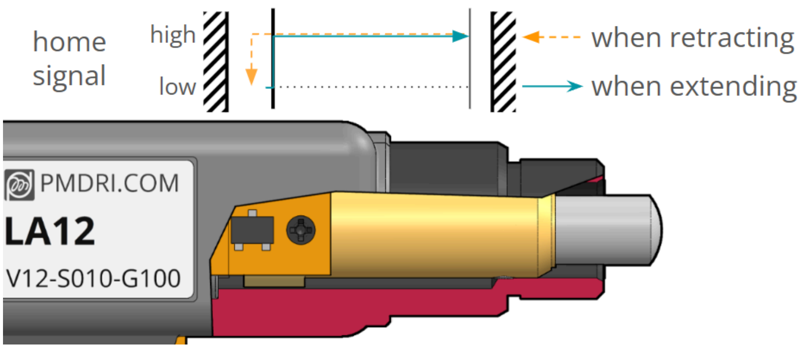
When power is resumed, the position of the actuator cannot be guaranteed to be known. Therefore, as above - we recommend that you check the home sensor and retract slowly until the sensor goes LOW. You'll then be in the HOME position.

6. HOME position hysteresis

The HOME Hall sensor has built-in hysteresis, and the lead screw assembly has mechanical backlash. This means that the mechanical position of the actuator will be different between:

- The 'extended' side of the HOME position - i.e. you're moving from the HOME position towards the operating zone - the point at which the home Hall sensor goes from LOW to HIGH.

- The 'retracted' side of the HOME position - i.e. you're arriving into the HOME position from the operating zone - the point at which the home sensor goes from HIGH to LOW.



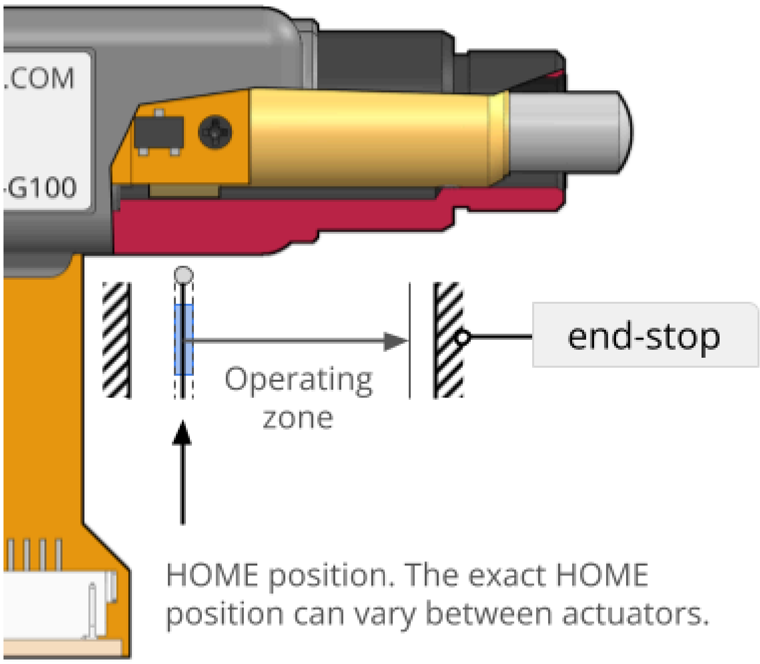
If you set your datum to one of these sides - we recommend the 'extended' side, you'll have a reliable HOME datum for <u>that</u> actuator.

⚠ NOTE : Due to manufacturing tolerances, Hall sensory hysterisis, 'home' magnet variations, and backlash variances, HOME datums can vary between identical actuators by as much as +/- 0.5mm.

7. HOME position tolerances

The mechanical position (relative to the mounting point / datum (i.e. ears / shoulder) of each actuator's HOME position, will vary from actuator to actuator because of:

- general mechanical stack-ups of the internal components of each actuator,
- the exact hysteresis characteristics of the HOME Hall sensor,
- the exact magnetic properties of the neodymium magnet embedded into the leadscrew sliding carriage,
- the backlash characteristics of the leadscrew and carriage for that actuator.



Therefore, whilst the HOME datum positional repeatability of an individual actuator will be very good (~80um), the HOME position could vary by up to 0.5mm between different actuators.

8. HOME datum calibration

If you need a datum to be the same across a field of actuators, you'll need to calibrate each one against a calibration datum, and record the offsets between those positions and the HOME datums for each actuator.

Then once at a HOME datum (e.g. on the 'extended' side of the HOME position), move the actuator by the recorded offset (measured during calibration) for each actuator, and they will align perfectly across a group of actuators.

One way of finding a calibration datum is to slowly drive each actuator into a known position - e.g. against a calibration stop. An effective way to do this is to run the motor at 10~15% power towards the calibration stop. When it meets the mechanical calibration stop, the linear slide will also stop, and the current will increase. Power to the motor can be cut, and the number of encoder or hall sensor pulses from the HOME datum can be recorded and used as an offset. A slightly higher power can be used to reverse the actuator away from the calibrated stop, being mindful not to overshoot the HOME position on retraction.

Another way is to use the breaking of an optical beam. Usually this is done once when an application machine is assembled.

9. Sprung tips

Sometimes we manufacture actuators with sprung tips. These are useful for soaking up external movement tolerances and applying a consistent force. Also, in some applications it's necessary to drive into an external application hard-stop (but not an actuator end-stop), and the spring will absorb the residual inertial momentum of the motor when the power is cut, reducing the chance of a leadscrew bind up.

It's worth mentioning that springs add another (significant) element of positional tolerance / variation from actuator to actuator, but the calibration process in step 8, and use of a calibration datum, should take any spring variations between actuators into account.

10. Support

If you do need further support, our friendly and experienced application engineering team are available:

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

11. 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 planetary types. These changes are primarily made to enhance the longevity, or to meet electromagnetic or arc / spark / naked flame environment requirements. We can also offer customer mounting and electrical connections, and complete linear actuator assemblies.