M3-LS-U2-8 Linear Smart Stage

Best Practices to Operate M3-LS-U2-8 Stages in Extended Life and High Duty Cycle Applications

For Extended Life Applications

The lifetime of M3-LS-U2-8 Linear Smart Stages (Figure 1) is largely dependent upon the use case. At New Scale Technologies, stages were life tested horizontally with random moves, with a 20 gram load offset 8.75 mm at the reverse position (see Figure 2). Test data indicates that there are some best practices to extend the lifetime of the stages.

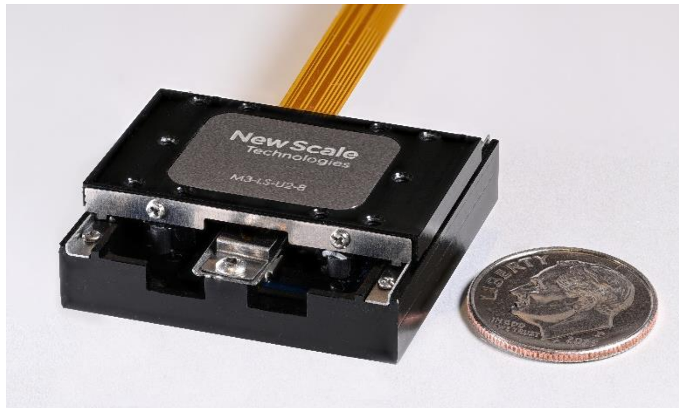

Figure 1. M3-LS-U2-8 Linear Smart Stage

The accumulation of debris will occur over time as the M3-LS-U2-8 linear stages run because the motor used in these stages is based on a frictional drive mechanism, leading to small amounts of wear over time. As debris builds up over time, it can affect the motion reliability of the stage; this may present itself as a stall, or not reaching a commanded move within the defined positional tolerances from target within the desired timeframe.

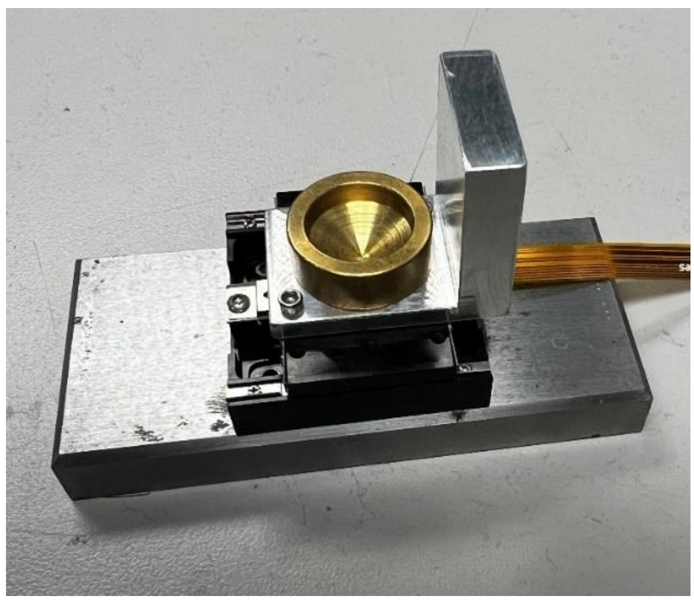

Figure 2 – Setup for a life test at New Scale Technologies of the M3-LS-U2-8 Linear Stage, using a 20 gram load, offset 8.75 mm at the reverse position.

For a commanded move in a closed-loop operation, you have the option to enable stall detection, then set a stall tolerance. In New Scale Pathway™ Software, you can change these settings in the **Axis Attributes** tab, within the **Closed Loop** section. We recommend enabling stall detection and adjusting both the **Max Position Error** and **Max Incremental Error*** parameters judiciously. Stall detection will help stop a commanded move when a large error is detected; these errors can occur either due to physical obstruction or the commanded move apparently fails. This will prevent unnecessary motor wear and elongate the life of the stage.

* For the life test in Figure 2, Max Position Error: 500 µm and Max Incremental Error: 50000. The incremental error rises quickly, so to ensure the motor/stage is given sufficient opportunity to reach the target, a value of no less than 20000 is recommended.

The probability of failed moves varies greatly depending on the use case. For example, the larger your positional tolerance allowance at the target position, and the longer you allow for the stage to settle to the target position, the lower the probability of a failed move. All things being equal, the failed move probability will increase over time as total distance travelled increases. As an example, in the life test setup in Figure 2, the time allowed to move to the target position was 0.5 seconds, and the position tolerance was ≤ 1 µm. When a stage is new, the failed move probability is << 0.1% with an average positional error of about 2 to 5 µm for these failed moves. With routine conditioning of the stage (described below) of every 1 m of travel, as the total distance traveled of a stage approaches 50 km (the rated lifetime of the M3-LS-U2-8 linear stage), the failed move probability approaches 0.2% with average positional error of 10 to 20 µm for these failed moves. These data are preliminary, and more testing is ongoing.

It is important to note that a failed move is recoverable, and it is *not* the end of life for the stage, whether the final position of a move is not within the specified positional tolerance, or there is a detected stall error. If you issue the command again to move to the missed target, the stage should be able to move to that target with high probability. It is recommended you monitor each move, and re-issue the move command if it is determined that the stage position is not within tolerance.

Our life test data for the stall errors indicates that the large majority (>> 95%) of the stall errors occur in the region 1 mm closest to the forward and reverse limits (i.e. between 0 mm – 1 mm and 7 mm – 8 mm). This is due to the operation of the motor pushing wear debris towards the travel limits during regular use. Therefore, we recommend operating the stage within the middle 6 mm travel region inside the stage's travel limits (i.e. 1 mm – 7 mm); the closer towards the middle of the travel range, the better.

We also recommend performing routine conditioning of the stage (command <49 01>, as described in our *Command-and-Control Reference Guide*) to intentionally push the wear debris towards and beyond the ends of the normal travel regions. By design, the absolute physical limits of the stages are slightly more than the normal 8 mm travel limits; this conditioning can push the debris beyond those normal travel limits and ensures good performance over the full useable travel limits. It takes about 4 cycles of full moves between physical limits (total ~ 60 mm to 70 mm travel) to condition the stage and it usually finishes the conditioning cycle very quickly, in about 2 seconds.

Figure 3 provides an example of the stall probability, as a function of condition cadence, based on a test result. Without any conditioning, the total failed move probability, including those small final positioning errors that do not trigger the stall detection, could be 2 to 10 times higher than if you had implemented a routine conditioning cadence. It is evident that the more frequently a stage is conditioned during stage, the lower the probability of a stall and total failed move.

We recommend regular conditioning after every 5 m of stage use, or even more frequently, to reduce the probability of stalls, failed moves and to elongate the life of the stage. If your application allows, conditioning every 1 m of stage use will be most effective.

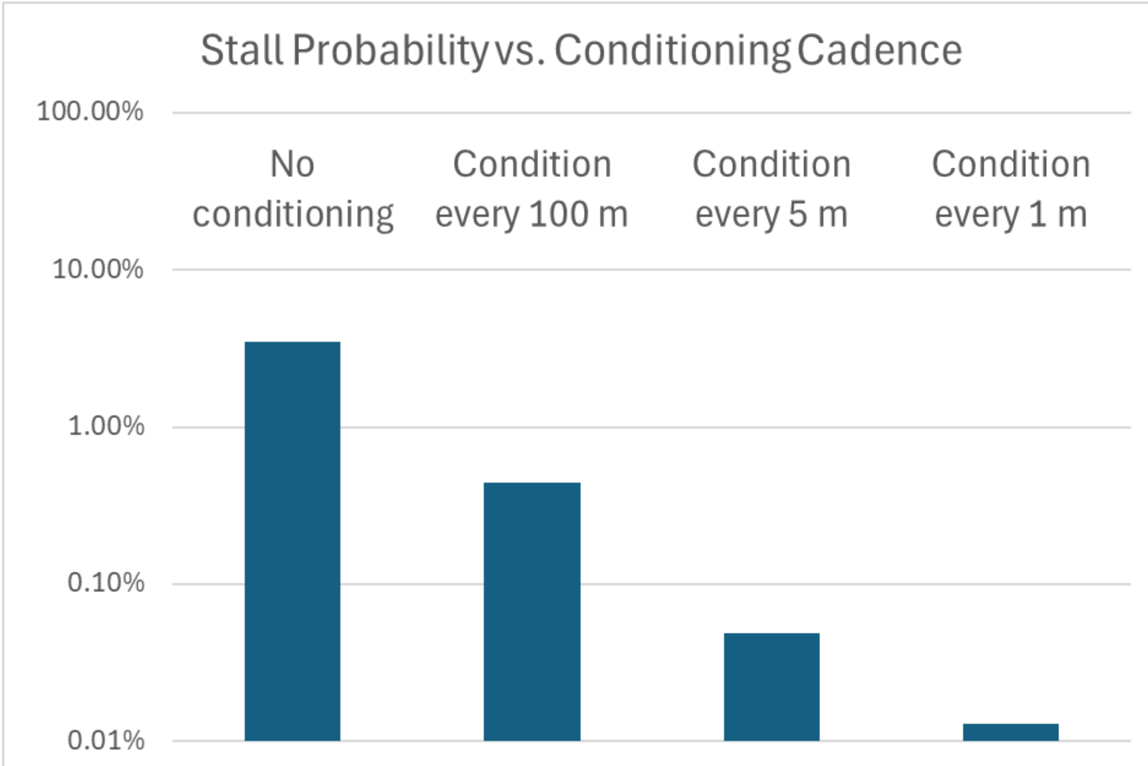

Figure 3. Stall probability for each stage move as a function of stage conditioning frequency.

For applications where motion targets are between two fixed, unchanging locations (i.e. constant moves between positions A and B), the contact wear at those targets is more severe than applications with random and changing target locations. The life of a stage in applications moving mostly among two defined targets (positions A and B) is typically shorter than that of applications moving among random target locations.

Please Note: The M3-LS-U2-8 F/W Version 5.8.0 keeps track of motion statistics for the current power cycle. These statistics (e.g., total closed loop travel distance, close loop motion commands received, etc.) can be queried by the host system via the D0 command. See the command-and-control reference guide for more information about the D0 command and reply formats.

For High Duty Cycle Applications

The input power of the M3-LS-U2-8 stage can be as high as 3.2 W for peak operation. When stages exceed 70˚C, as measured by the internal temperature sensor, a stall error can occur; if it is integrated with poor heat sinking, the ambient temperature of the stages could be as low as 50˚C, making a stall more likely to occur. It is important to note that this stall error is *not* permanent, and it is recoverable when the stage cools down. To mitigate the stage heating, it is strongly recommended to integrate the stage with good heat sinking, especially for high duty cycle applications. For example, mount the stage on an aluminum plate (as shown in Figure 2), and/or use fans to promote convection.

A < 50% duty cycle is recommended for operating at room temperature (≤ 25°C).

In summary, these are the best practices to elongate the M3-LS-U2-8 stage life and prevent stall errors in high duty cycle applications:

1. Enable stall detection during closed loop operation.
2. Monitor stage position, and re-issue move commands if there is a stall error or a failed move due to the stage position not arriving within the specified target tolerances.
3. Operating at numerous, variable positions is better than moving among fixed target positions (A-B move).
4. Avoid operating within 1 mm of the stage travel limits; try to operate towards the middle 6 mm of the travel, and the closer to the middle, the better.
5. Perform routine stage conditioning (command <49 01>) at least every 5 m of travel, or preferably every 1 m of travel, if permissible in your application use case.
6. Provide sufficient heat sinking of the stage, especially for high duty cycle applications, and maintain < 50% duty cycle.

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