ACCELERATED LIFE TESTING OF LCLS-II CAVITY TUNER MOTOR

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Abstract

An Accelerated Life Test (ALT) of the Phytron stepper motor used in the LCLS-II cavity tuner is being carried out at JLab. Since the motor will reside inside the cryomodule, any failure would lead to a very costly and arduous repair. As such, the motor will be tested for the equivalent of five lifetimes before being approved for use in the production cryomodules. The 9-cell LCLS-II cavity will be simulated by disc springs with an equivalent spring constant. Hysteresis plots of the motor position vs. tuner position – measured via an installed linear variable differential transformer (LVDT) – will be used to determine any drift from the required performance. The titanium spindle will also be inspected for loss of lubrication. This paper outlines the ALT plan and latest results.

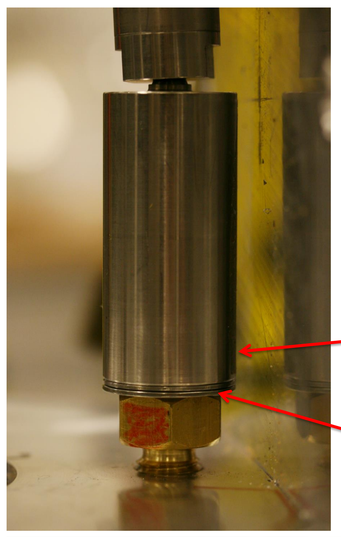
Test Setup

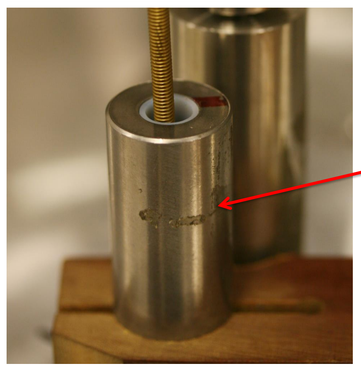
- The motor and tuner assembly are attached to an Aluminum testing block, and positioned in a test can. The can is cooled to 4K in the JLab vertical test area (VTA) for testing.
- The position of the tuner lever arm is measured by readings from an attached LDVT
- The cavity is simulated by means of disc springs, with a combined stiffness of 3kN/mm
- The temperature readings are from a diode attached to the motor housing.

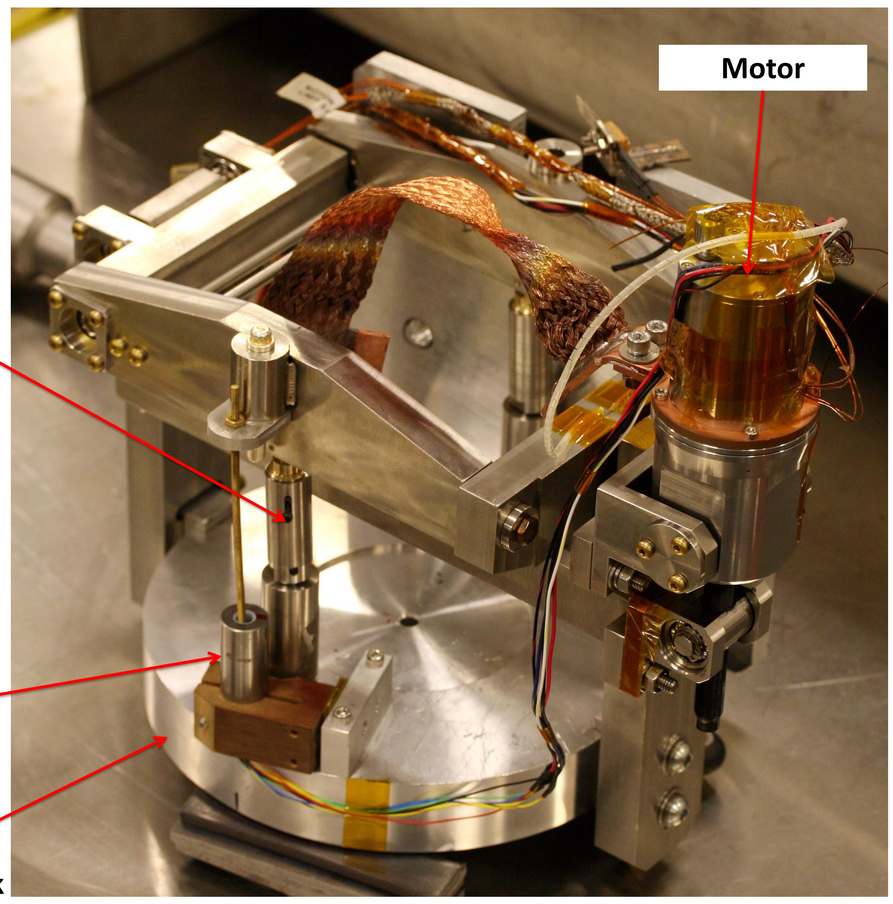
Test Plan

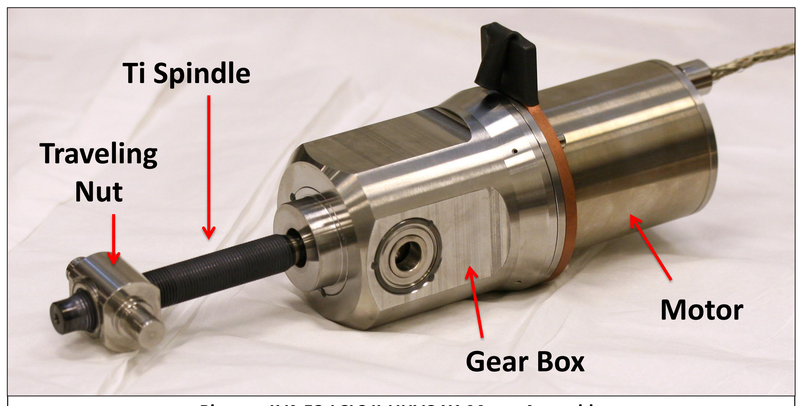
- The motor will be cycled 5.5 x 10^6 micro-steps, which represents +/- 10 bandwidths (+/- 300 MHz) of the cavity tuning
- In operation, the motor is predicted to be actuated once per day at this stroke, and twice per year at its full stroke (26 mm) when the cryomodule is warmed up.
- Each year of simulated operation will encompass 330 cycles. A single lifetime is 20 years, and a total of five lifetimes will be tested. The table below outlines the inspection schedule
- The "Initial Parameter Test" will determine the parameters to be used in the full ALT

Inspection Name	Cycles
Initial Parameter Test	50 – 100
Initiation Failure	~3300
Single Lifetime	~6600
Four Lifetimes	~26,400
Five Lifetimes	~33,000







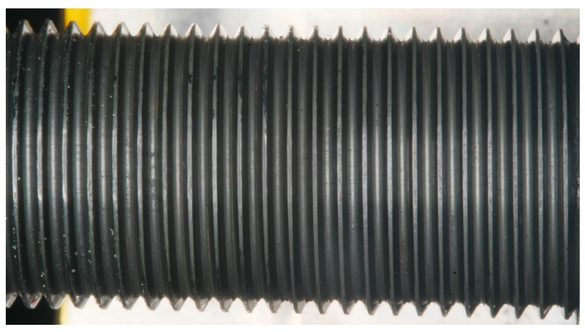


Phytron LVA 52-LCLS II-UHVC-X1 Motor Assembly	
Motor Operating Condition	Insulating Vacuum
Motor Operating Temperature	20K – 60K
Motor Lifetime	1000 revs (20 years)
Motor Current	1.2A
Motor Force	+ 1300N, -200N
Gear Ratio	1:50

Results

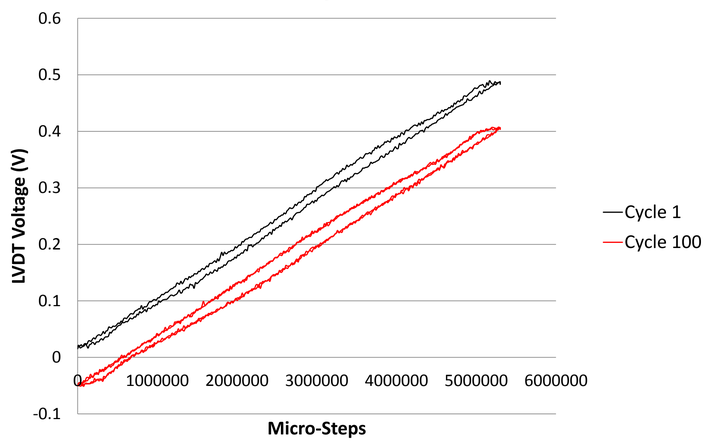
A summary of the test results are shown in the graphs below. The parameters used on the tests can be found in the table to the right. The following observations were made:

- The stabilized temperature in Test 1 was far higher than desired (112K)
- Though Test 2 stabilized at a lower temperature (80K), the time taken to complete just 45 cycles would make the full ALT impractical
- The dwell time added to Test 3, as well as the reduced current, made its stabilized temperature nearly as low as Test 2, while being over twice as fast. However, the hysteresis plot on the bottom left shows a large amount of drift. This could possibly be due to non-linear behaviour of the disc springs simulating the cavity, or small thermal contractions
- The photo below shows the titanium spindle after ~200 cycles. It shows no damage or loss of lubrication

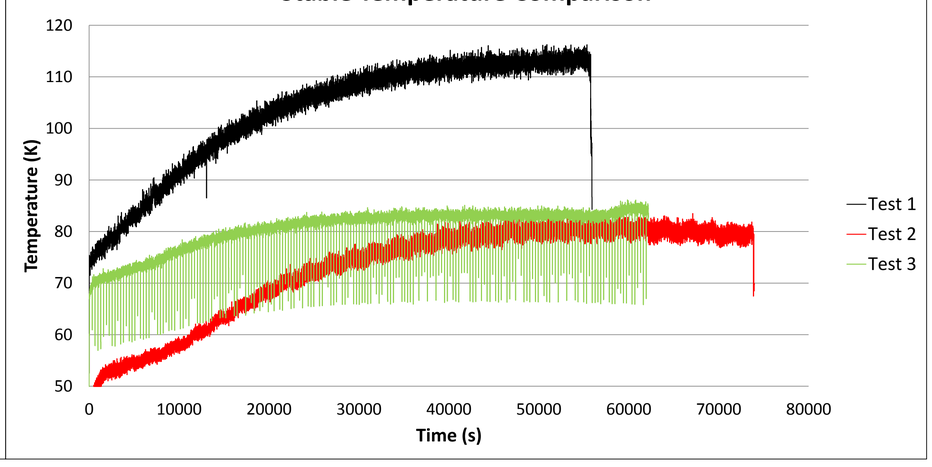


Parameter	Test 1	Test 2	Test 3
Motor Speed	10 rev/s	5 rev/s	10 rev/s
Motor Acceleration	2 rev/s^2	0.5 rev/s^2	2 rev/s^2
Motor Deceleration	2 rev/s^2	0.5 rev/s^2	2 rev/s^2
Dwell Time	0 s	0 s	5 s
Motor Current	1.4 A	1.4 A	1.2 A
Cycles	30	45	100
Results			
Stable Temperature	112K	80K	83K

Test 3 Hysteresis Plot



Stable Temperature Comparison



Further Work

- A copper strap will be attached to the motor collar, and connected to the inside surface of the test can, which is conductively cooled by liquid helium This will result in faster cooling.
- A second temperature diode will be added to the tuner frame. The current diode's close proximity to the motor leads to unsteady temperature readings.
- The operating current of the motor can be dropped significantly. It was found that the tuner lever arm will function at a minimum current of 0.70 A.
- An analysis will be conducted of the spring constant of the disc spring currently in the test setup, to ensure that suitable forces are being imparted

References

[1] Y. Picschalnikov, C. Grimm, R. Pilipenko, H. Brunke, W. Lahmadi, "Tests of Electromechanical Actuators for SRF Cavity Tuner", IPAC15, Dresden, Germany
[2] Y. Picschalnikov, "LCLS-II Tuner – Internal Review of the Modified Design", FNAL, December, 2014

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