

The Development of the Undulator Controls Module at the Linac Coherent Light Source Arturo Alarcon

Introduction

The Linac Coherent Light Source, LCLS, at the SLAC National Accelerator Laboratory, SNAL, is the first hard x-ray Free Electron Laser. The Undulator Controls Module, UCM, controls five cams and two translation stages that regulate the position of each of the 33 permanent undulator magnet segments within 10 microns. The UCM package, hardware and software, was designed and built by the Advanced Photon Source at Argonne. The UCM is still evolving, and many improvements can still be made to provide and more user friendly and stable control system. A functional diagram of the current system, from the perspective of the user, is shown below.

| | UCM Global | Controls E | lome Screen Exit |
|----------------|--------------------------------|-----------------|------------------|
| | | | - |
| | | STOP ALL MOTORS | J |
| | Undulator 1 | Undulator 12 | Undulator 23 |
| | Undulator 2 | Undulator 13 | Undulator 24 |
| | Undulator 3 | Undulator 14 | Undulator 25 |
| | Undulator 4 | Undulator 15 | Undulator 26 |
| | Undulator 5 | Undulator 16 | Undulator 27 |
| | Undulator 6 | Undulator 17 | Undulator 28 |
| ed functions | Undulator 7 | Undulator 18 | Undulator 29 |
| vailable from | Undulator 8 | Undulator 19 | Undulator 30 |
| lobal Controls | Undulator 9 | Undulator 20 | Undulator 31 |
| ntrol all or a | Undulator 10 | Undulator 21 | Undulator 32 |
| ion of | Undulator 11 | Undulator 22 | Undulator 33 |
| | Select ALL | Deselect ALL | |
| ator segments. | | | |
| | Menu | Reboot | |



| ITD Ten | npera | ture l | Monit | ors | ĸ | | | | | Home S | creen | E |
|--------------|-------|--------|-------|-------|-------|-------|-------|-------|-------|--------|-------|-------|
| Tomporaturas | | | | | | | | | | | | |
| remperatures | T01 | T02 | T03 | T04 | T05 | T06 | T07 | T08 | Т09 | T10 | T11 | T12 |
| Und-01 | 19.49 | 19.83 | 19.70 | 22.79 | 19.56 | 19.68 | 19.56 | 20.75 | 19.69 | 21.72 | 19.55 | 36.00 |
| Und-02 | 19.86 | 19.81 | 19.63 | 21.51 | 19.84 | 19.66 | 19.66 | 21.65 | 19.70 | 23.18 | 19.72 | 23.50 |
| Und-03 | 19.73 | 20.18 | 19.83 | 28.27 | 20.14 | 19.86 | 19.35 | 22.28 | 19.92 | 20.37 | 23.95 | 25.71 |
| Und-04 | 19.97 | 19.58 | 19.68 | 25.07 | 19.93 | 19.74 | 19.64 | 22.23 | 19.77 | 24.16 | 20.08 | 23.16 |
| Und-05 | 20.02 | 19.81 | 19.71 | 24.24 | 19.88 | 19.71 | 20.24 | 22.12 | 1.36 | 23.26 | 20.55 | 23.64 |
| Und-06 | 20.12 | 20.18 | 19.81 | 24.40 | 20.51 | 19.79 | 20.05 | 22.47 | 19.83 | 24.10 | 20.31 | 26.17 |
| Und-07 | 20.09 | 19.90 | 19.90 | 24.01 | 19.90 | 19.85 | 19.83 | 22.37 | 19.89 | 24.42 | 20.15 | 23.97 |
| Und-08 | 20.13 | 20.18 | 19.94 | 24.98 | 19.90 | 19.91 | 20.10 | 22.50 | 19.92 | 24.55 | 20.10 | 23.20 |
| Und-09 | 19.76 | 20.25 | 19.71 | 25.68 | 20.00 | 19.97 | 20.03 | 21.88 | 19.95 | 24.20 | 20.18 | 23.48 |
| Und-10 | 20.29 | 19.93 | 19.97 | 24.09 | 20.13 | 19.93 | 19.99 | 20.70 | 19.91 | 24.07 | 19.87 | 24.07 |
| Und-11 | 20.02 | 19.58 | 20.03 | 24.66 | 20.17 | 19.97 | 20.03 | 22.77 | 20.12 | 24.44 | 20.02 | 23.41 |
| Und-12 | 20.02 | 20.04 | 19.97 | 24.08 | 20.15 | 19.95 | 20.16 | 22.99 | 19.95 | 23.95 | 19.87 | 22.70 |
| Und-13 | 19.96 | 19.24 | 19.92 | 24.93 | 19.82 | 20.06 | 19.73 | 22.08 | 19.84 | 24.26 | 19.88 | 22.78 |
| Und-14 | 20.21 | 20.14 | 19.96 | 24.33 | 20.18 | 19.88 | 20.32 | 22.52 | 19.91 | 24.08 | 20.34 | 23.55 |
| Und-15 | 20.44 | 19.90 | 19.88 | 24.49 | 20.20 | 19.88 | 19.88 | 23.01 | 19.88 | 24.04 | 19.72 | 25.48 |
| Und-16 | 20.18 | 19.83 | 19.93 | 24.95 | 20.18 | 19.86 | 20.10 | 22.68 | 19.97 | 24.12 | 20.36 | 23.23 |
| Und-17 | 19.96 | 20.35 | 19.97 | 23.90 | 19.39 | 19.90 | 20.02 | 22.39 | 20.02 | 23.78 | 20.65 | 25.93 |
| Und-18 | 19.82 | 19.96 | 20.02 | 24.84 | 20.25 | 20.01 | 20.15 | 22.78 | 20.05 | 23.71 | 20.46 | 26.04 |
| Und-19 | 20.31 | 20.20 | 19.99 | 25.46 | 20.20 | 20.00 | 20.04 | 22.59 | 20.02 | 24.26 | 20.05 | 23.32 |
| Und-20 | 19.84 | 19.22 | 20.03 | 24.41 | 20.78 | 19.99 | 19.74 | 23.40 | 20.01 | 25.21 | 20.17 | 23.99 |
| Und-21 | 19.82 | 20.27 | 20.09 | 26.34 | 20.47 | 20.05 | 19.82 | 21.31 | 20.05 | 23.63 | 20.12 | 24.27 |
| Lind 22 | 19.73 | 19.84 | 19.98 | 24.44 | 20.30 | 10.04 | 20.04 | 22.67 | 20.04 | 24.32 | 19.78 | 24.36 |

Undulator Control Module Interface, UCMI, built

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Quadrupole magnet.

Transla

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다 Girde



| | $Y = A + B^*X + C^*X^2 + D^*X^3 + E^*X^4 + F^*X^5$ | Skew level2 recovery intructions. | |
|---|--|---|--|
| | K vs. x Y KACT x vs. K Y -XDES mm X -XACT mm X KDES-3.5 KDES-3.5 A A 3.498631e+00 Mm ⁻¹ A 5.008442e-01 mm B 2.767141e-03 mm ⁻² C 1.931101e+03 mm | Linear Potentiometers TMX Motio Debug | D Smart Monitor |
| GO BFW QUAD GO Ctl, absolute (um) Mon (um) Ctl, absolute (um) Mon (um) | D -6.231973e-07 mm ⁻³ D 6.314478e+04 mm E -2.528956e-07 mm ⁻⁴ E 5.787548e+06 mm | motors page. | Skew level2 recovery instructions |
| X = 0.00 -173.02 X = 0.00 117.02 Y = 0.00 -14.08 Y = 10.00 33.21 ROLL Ctl (radians) Mon 0 -0.000014102 Translation Motion XIN Undulator IN position 0.099 mm GO OUT Undulator OUT position 80.000 mm GO POS1 Last BBA Position, don't touch! -0.104 mm GO POS3 0.000 mm GO GO POS4 0.000 mm GO GO | F -2.166312e-08 mm ⁻⁵ IIX vs. x Y IIX uTm A 1.325998e+01 uTm A 1.325998e+01 uTm B -4.706527e-01 uTm/mm C 1.301004e+00 uTm/mm ² D 2.461699e-02 uTm/mm ⁴ F -1.676568e-03 uTm/mm ⁴ F -1.676568e-03 uTm/mm ⁴ F -1.676568e-03 uTm/mm ⁴ F -5.747367e-03 uTm ² /mm ⁴ F -5.747367e-03 uTm ² /mm ⁴ F -1.274914e+01 uTm/mm ² B -1.274914e+01 uTm/mm ² D 6.6772884e-01 uTm/mm ³ E 2.610868e-02 uTm/mm ⁴ F -8.126185e-03 uTm/mm ⁵ | | Steps 1 Access into the undulator hall is required for the skew level 2 recovery. BTH Access State 10 2 You'll need a multimeter with standard probes and a small flat scredriver (tweaker) 3 Go the to appropriate segment and open the mini rack underneath it. 4 4 You should see three red lights in the front of the Undulator Controls Module Interface (UCMI). If that's recase, you might not be at the correct segment with the skew level2 fault. 5 Using your multimeter connect the probes betweent the "GND" and "Level& Threshold TP" test points in of the UCMI. It should read about 18mV. 6 Using your tweaker, slowly rotate the "Level2 Threshold Adj." pot counterclockwise until you add 10mV original reading from step 5. 7 At this point, the skew level2 should be gone, and only a skew level1 should be present. Interlock Status OK 8 If the interlock status is now skew level1, the power should be restored to the motors. Is the 42V back? 42V is still missing, a fuse may be blown in the back or within the Undulator Motor Power Interface (UMF 42V Power Supply: 41.51 Voits 8 Check that all motors have power back by looking at each motor and making sure there is a red LED on are five cam motors and two translation stage motors. If a motor doesn't have power, a fuse may be blow |
| Detailed girder motion controls. | Temperatures | | back of the UCMI. 10- If all motors have power, you can now restore the motor positions. |
| | Undulator fiel | lds calculations page. | If a motor cannot be restored, or it complains of a motor communication error, power cycle the and reboot the ioc. To power cycle the motors, cycle one of the ESTOP buttons around the girder. Push one of th ESTOP buttons that has a key until it lathces in, verify the 42V goes away, unlatch the buttor turning the key, and verify that all motors regain power. Reboot the ioc. Hard Reset IOC Heartbeat If the ioc heartbeat does not return after four minutes of exercising a hard reset, push the hard n again. Do so, every four minutes, until the ioc returns. |
| | USEG:UND1:450 RTDs | Exit | 11- If all motors are restored, you are ready to fix the level1 skew. |
| | Calibrations Raw (V) Offset Slope Corrected Include? In use? RTD03 0.92 1.33 20.00 19.70 Degrees YES NO YES YES | RTD data acquisition Serial Number Temp correction Start Stop \$TOPPED \$44 OFF Start Stop STOPPED 0 ON Start Stop STOPPED 80 MMF temp of 20.07 deg C -0.34 -0.34 -0.34 | No message 12- If the level1 skew fix is successful, and the interlock status shows Ok, you must now restore the level2 To do so, turn the "Level2 Threshold Adj." pot, on the UCMI, clockwise until it reads about 25mV. 13- Now you should exercise all the motors to make sure they respond correctly. Move each cam a few d Move the translation stages through their whole range, from their current position to -5, then to 80, and from 80 to the desired position. 14- If all motors respond correctly, you are done! If not, try restarting from step 8, otherwise call an expert. If another level2 skew fault is generated during checkout, call an expert. |
| | Undulator fields temperature correction page. | | Skew interlock recovery instructions. |