# NGAO OSM

Design Study

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08/05/2009
Version 9

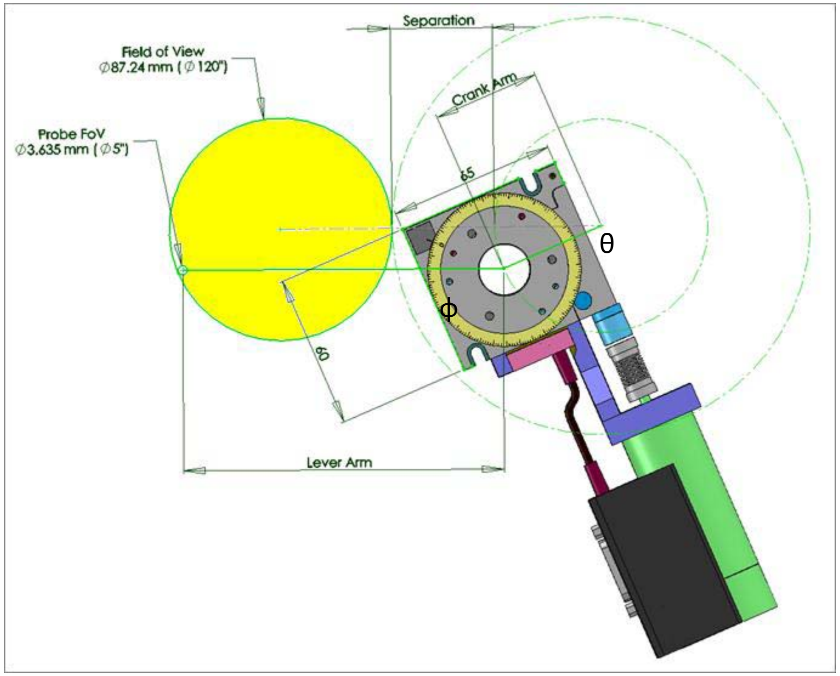
# 1. Conceptual design and operation

The Ø 5” (3.635 mm) probe covers the entire Ø 120” (87.24 mm) Field of View.

The 2 degrees of freedom probe arm consists of 2 individual arms: A crank arm and a lever arm, driven by 2 corresponding rotation motors: The crank and lever motors.

Any position in the OSM field of view can be acquired by calculating appropriate values for theta and phi, noting that due to a mirror reflection there are always 2 possible solutions.

The crank motor is secured to the Sensor and rotates the crank arm, precisely about the rotation axis of the crank motor referred to as the theta axis. The lever arm motor provides the necessary second degree of freedom by rotating the lever arm and all associated optics, about the phi axis.




***1.1 Basic Design requirements:***

Mechanism Type: ϕ/θ

**Patrolled Field: Ø 120” (87.24mm)**

Probe FoV: Ø 5” (3.635mm)

Acquisition accuracy: 40 mas (30µm)

Stability: 5 mas / 3600s (1 µm)

Position knowledge: < 1 µm (TBC)

Minimum Incremental motion: TBD

Operating Temperature: -10°C +/- 0.3

*Note: Separation is a distance determined by the Lever Arm motor envelope to clear the Field of view at any angle of Crank rotation.*

***1.2 Position Accuracy***

Probe Position within the field shall be measured according to the level of desired accuracy: Direct or indirect.

Indirect measurement:

Total Position Accuracy of 30µm at the furthest position across the 144mm field requires a minimum crank rotation accuracy of:

$\sin \alpha = 30\mu m / 144\ mm \Rightarrow \alpha = 0.012° = .012\ \pi / 180 = .00021\ rad = 210\ \mu rad$

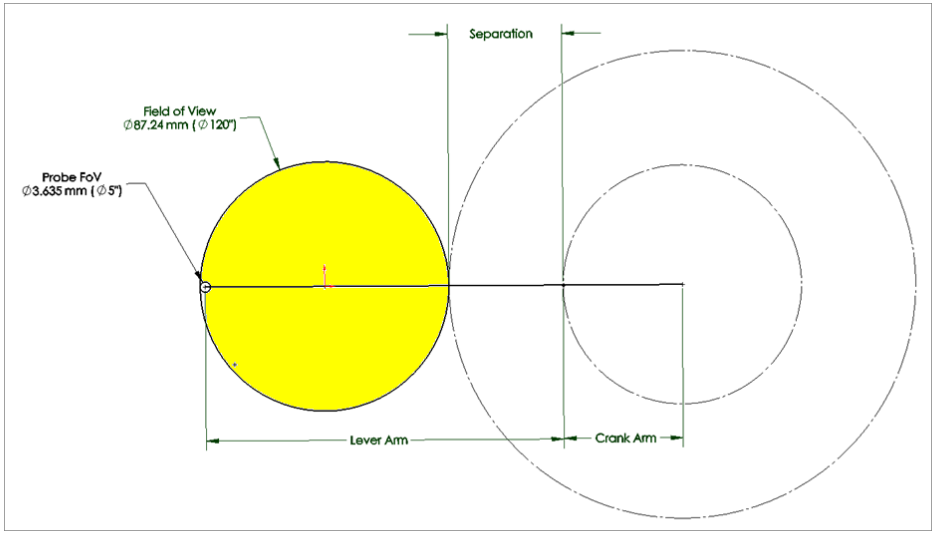
And the 100 mm lever arm motor is 60 % longer than the 40mm Crank arm

Crank motor rotation accuracy: 210 µrad x 60% = 126 µrad

Lever motor rotation accuracy: 210 µrad x 40% = 84 µrad

# 2. Arms Size Equation

***2.1 Arm fully extended Equation:***




2.1.1) Using 40 mm separation for the PI M-038 and M-037

Lever Arm + Crank Arm + 1.8175 Probe = 87.24 Fov + 40 Separation + Crank Arm

Lever Arm + 1.8175= 87.24 + 40 ➔ Lever Arm = 125.42 mm

2.1.2) Using 63.5 mm separation for the Newport URS75B

Lever Arm + 1.8175 = 87.24 + 63.5 ➔ Lever Arm = 148.9225 mm

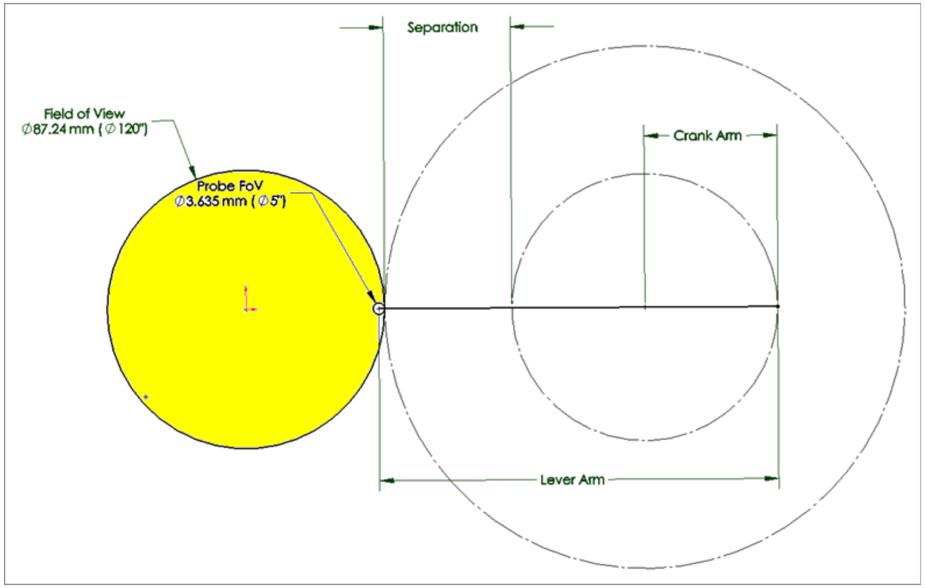
2.2.3) Using a 200mm Lever Arm, separation = Crank Arm + Fov = need to be:

200 + 1.8175 = 87.24 + Separation ➔ Separation = 114.5775 mm

2.2.4) Using a 230mm Lever Arm, separation need to be:

230 + 1.8175 = 87.24 + Separation ➔ Separation = 144.5775 mm

***2.2 Arm fully retracted Equation:***




2.2.1) Using 40 mm separation for the PI M-038 and M-037

Lever Arm - Crank Arm = Separation + Crank Arm + Probe

➔Crank Arm = 41.30 mm

2.2.2) Using 63.5 mm separation for the Newport URS75B

148.9225 - Crank Arm = 63.5 + Crank Arm + 1.8175

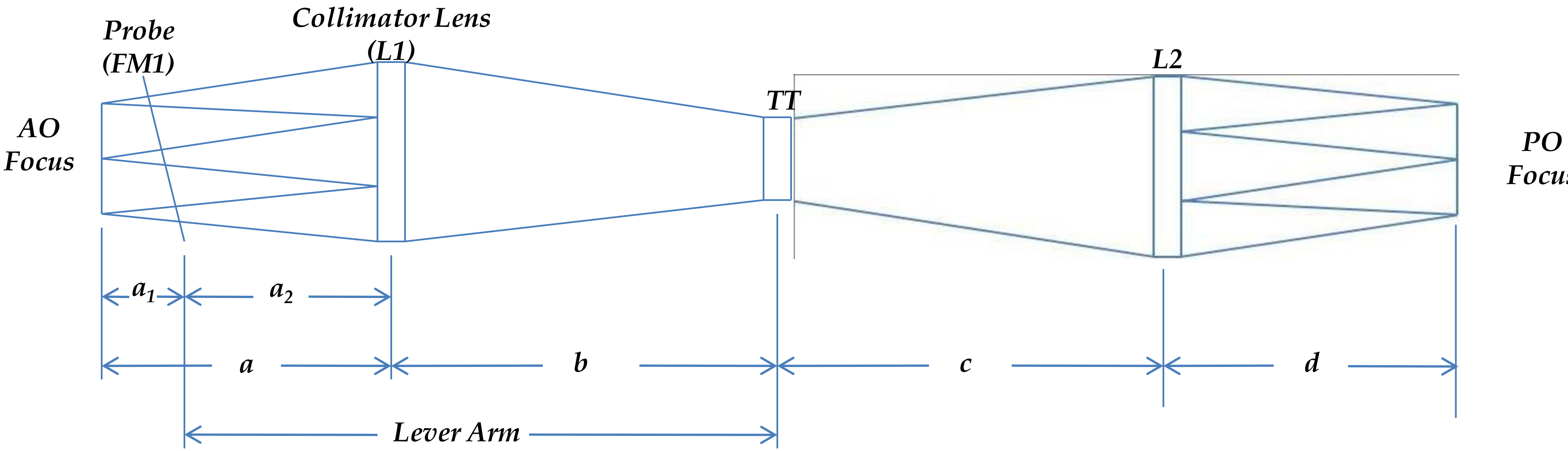
➔Crank Arm = 41.8025 mm

2.2.3) Using a 200 mm Lever Arm and 114.5775 mm Separation

200 - Crank Arm = 114.5775 + Crank Arm + 1.8175

➔Crank Arm = 41.8025 mm

# 3. Optical Equation




Optical Layout is optimized when the following equations are verified:

3.1) $a = b = c = d$

3.2) $a + b = x\,(c + d)$

Keeping the AO Focus away from the Probe mirror (FM1) gives:

3.3) $a = a_1 + a_2$

Keeping each Lever arms on a different plane to avoid collision between each other gives a different value of a1 for each OSM
The Lever Arm Length previously determined gives:

3.4) Lever Arm length $= b + a_2$

Replacing 3.3 & 3.4 in 3.1 gives: $a = b \Rightarrow a_1 + a_2 =$ Lever Arm length $- a_2$

Solving for $a_2 \Rightarrow 2a_2 =$ Lever Arm length $- a_1 \Rightarrow$ **$a_2 =$ (Lever Arm length $- a_1$)/2**

Using a 250mm Lever Arm , would give the following results :

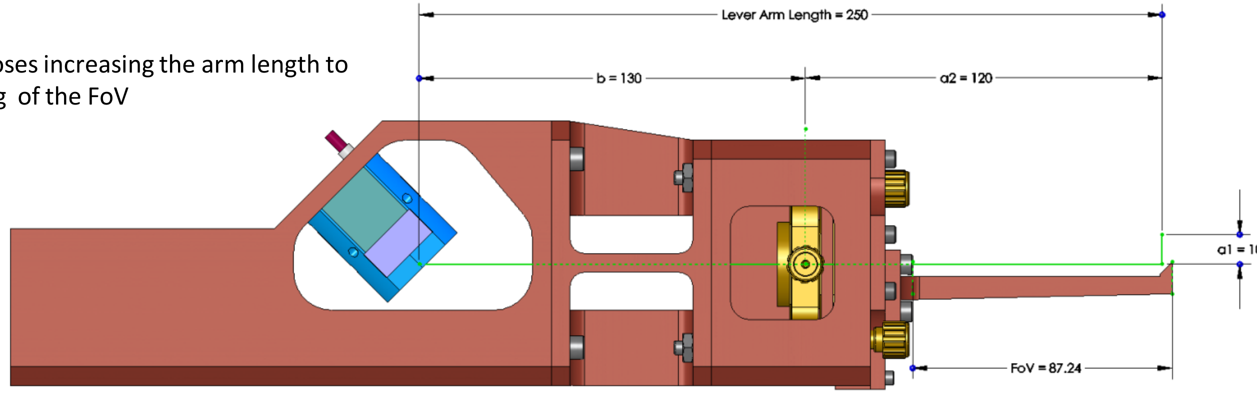
a1 = 10 mm for OSM #1 $\Rightarrow 10 + 2\,a_2 = 250 \Rightarrow 2a_2 = 250 - 10 \Rightarrow a_2 = 120$
a1 = -5 mm for OSM #2 $\Rightarrow -5 + 2\,a_2 = 250 \Rightarrow 2a_2 = 250 + 5 \Rightarrow a_2 = 127.5$
a1 = -20 mm for OSM #3 $\Rightarrow -20 + 2a_2 = 250 \Rightarrow 2a_2 = 250 + 20 \Rightarrow a_2 = 135$

| OSM# | $a_1$ | $a_2$ | $a=a_1 + a_2$ | a+b |
|---|---|---|---|---|
| I | 10 | 120 | 130 | 260 |
| II | -5 | 127.5 | 122.5 | 245 |
| III | -20 | 135 | 115 | 230 |

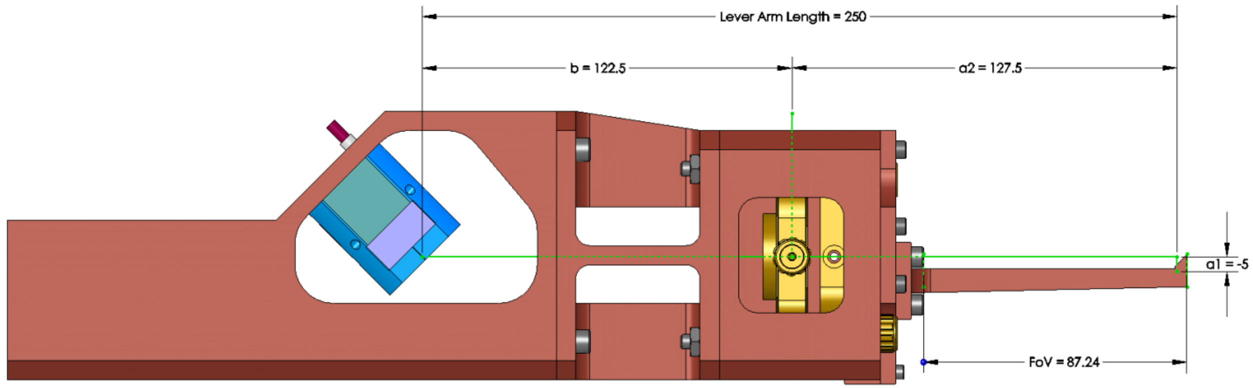
# 4. Lever Arm Design

Using a Lens holder imposes increasing the arm length to avoid eventual vignetting  of the FoV

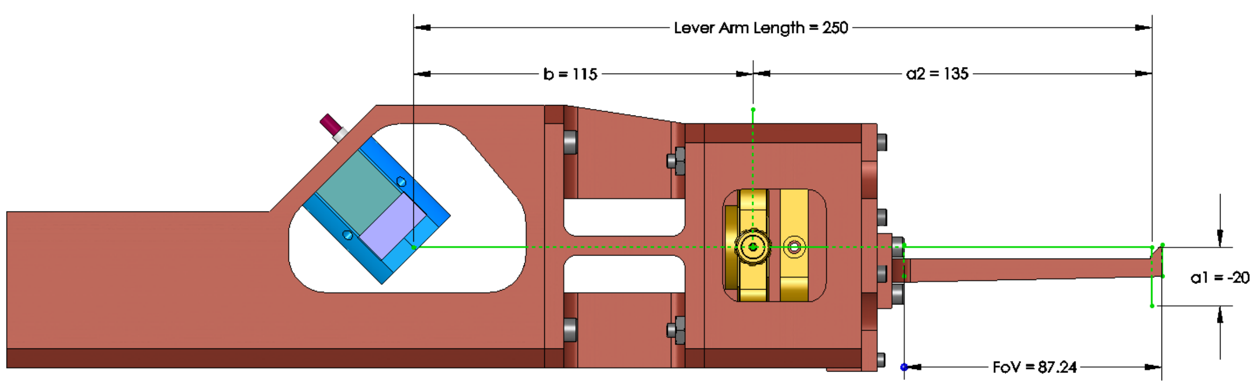
***OSM #2***
***(a1 = 10)***




***OSM #2***
***(a1 = -5)***




***OSM #3***
***(a1 = -20)***



# Compact Lens Positioners

NEW


LPV-1


LA1V-XY

- Positions 1.0 in. (25.4) optical elements
- Precision positioning using 100 TPI adjustment screws
- Compact size is ideal for limited-space applications
- English/metric compatibility

The new LA1V-XY and LPV-1 Compact Lens Positioners provide an economical solution for applications requiring two (XY) or five (XYZ $\theta_X\theta_Y$) axes of precision adjustment. Their compact size makes them ideal for OEM applications, or research projects with limited table space. Precise positioning is achieved with the integration of 100 TPI drive screws. Additionally, an integral 5/64 (M2) hex hole in the drive knobs allows for optional Allen key adjustment. Each unit is supplied with two non-marring Delrin retaining rings to safely secure optical elements with a maximum outer diameter of 1.0 in. (25.4mm). Post mounting on the LA1V-XY is achieved by accessing one of the tapped 8-32 or M4 threaded holes in the mount body. The LPV-1 is post mounted via a counterbored hole sized for 8-32 or M4 screws.

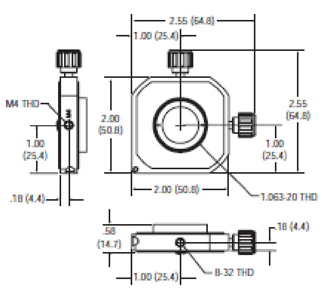
## Specifications

| | LA1V-XY | LPV-1 |
|---|---|---|
| Degrees of Freedom | XY | XYZ $\theta_X\theta_Y$ |
| Maximum Optic Diameter [in. (mm)] | 1.0 (25.4) | 1.0 (25.4) |
| Optical Axis Height [in. (mm)] | 1.0 (25.4) | 1.25 (31.8) |
| Range, XY [in. (mm)] | ±0.125 (3.2) | ±0.125 (3.2) |
| Range, Z [in. (mm)] | | ±0.18 (4.6) |
| Range, $\theta_X\theta_Y$ | | ±5° |
| Sensitivity, XY (µm) | 0.75 | 0.75 |
| Sensitivity, Z (µm) | | 1 |
| Sensitivity, $\theta_X\theta_Y$ (arc sec) | | 2 |

## Ordering Information

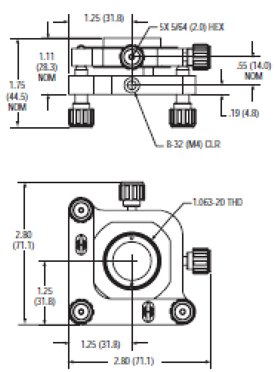
| Model | Description |
|---|---|
| LA1V-XY | XY Lens Positioner |
| LPV-1 | Five-Axis Lens Positioner |

### Model LA1V-XY



LA1V-XY

### Model LPV-1



LPV-1


*Rear View of the LPV-1*

### Related Products


*Post mounting options*
*(see page 705)*


*LP Series Precision Multi-Axis Lens Positioners*
*(see page 679)*


*BK 7 Precision Plano-Convex Lenses*
*(see page 457)*


*Precision Achromatic Doublet Lenses*
*(see page 467)*

CAD *See our website for CAD files*



Newport

LPV-1

Search for: LPV-1

## Model: LPV-1 | 5-Axis Compact Lens Positioners, 1-in. Diameter

Opto Mechanics > Lens Holders > Compact Lens Positioners

Available Today

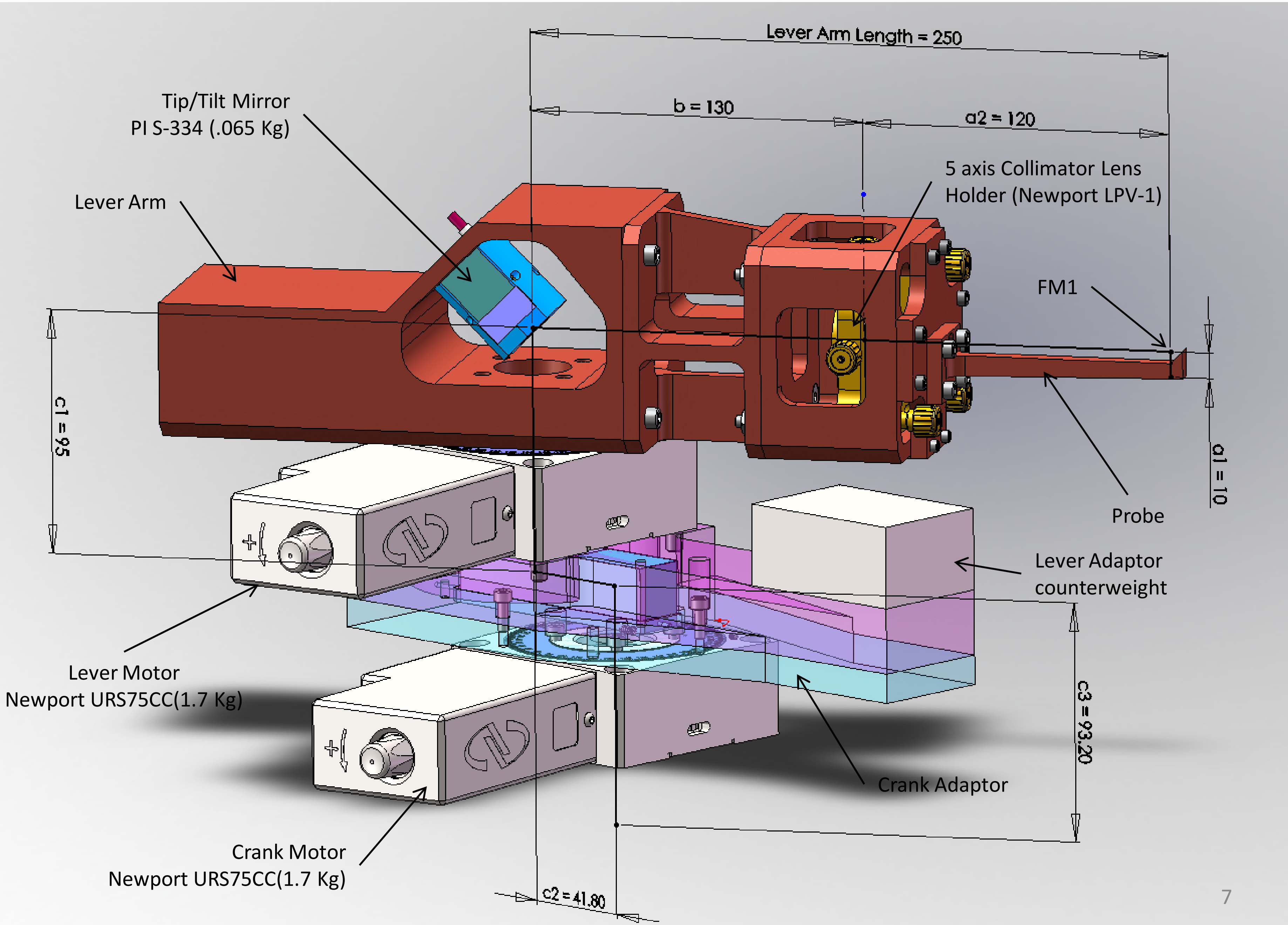
$249.99 | 1 | + Add to cart

- Diameter: 1.0 in. (25.4 mm)
- Adjustments: x, y, z, θx, θy

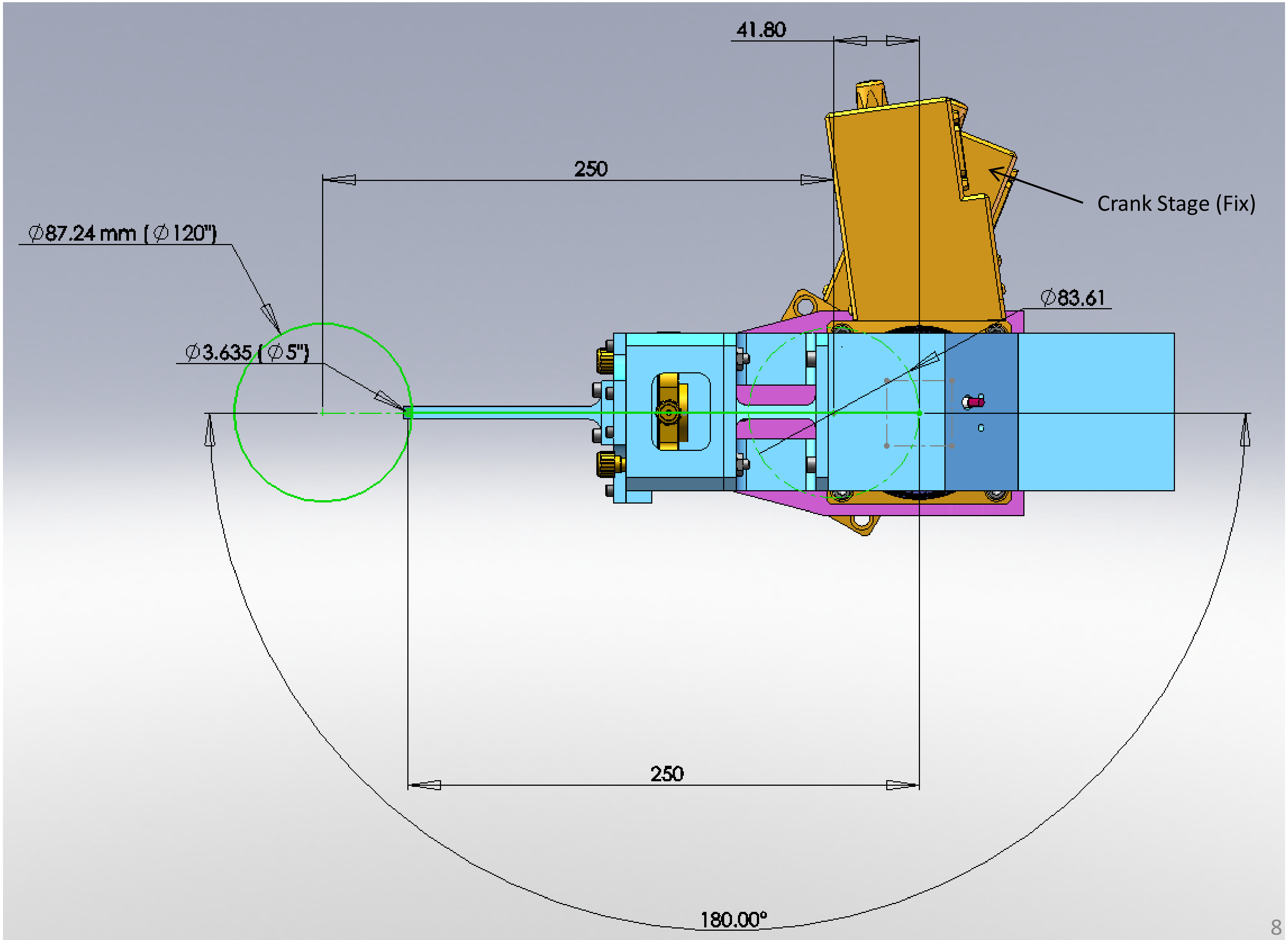
Catalog PDF | 3-D Model | Drawings | Description | Specifications | Product Detail

The new LA1V-XY and LPV-1 Compact Lens Positioners provide an economical solution for applications requiring two (XY) or five (XYZ $\theta_X\theta_Y$) axes of precision adjustment. Their compact size makes them ideal for OEM applications, or research projects with limited table space. Precise positioning is achieved with the integration of 100 TPI drive screws. Additionally, an integral 5/64 (M2) hex hole in the drive knobs allows for optional Allen key adjustment. Each unit is supplied with two non-marring Delrin retaining rings to safely secure optical elements with a maximum outer diameter of 1.0 in. (25.4mm). Post mounting on the LA1V-XY is achieve by accessing one of the tapped 8-32 or M4 threaded holes in the mount body. The LPV-1 is post mounted via a counterbored hole sized for 8-32 or M4 screws.

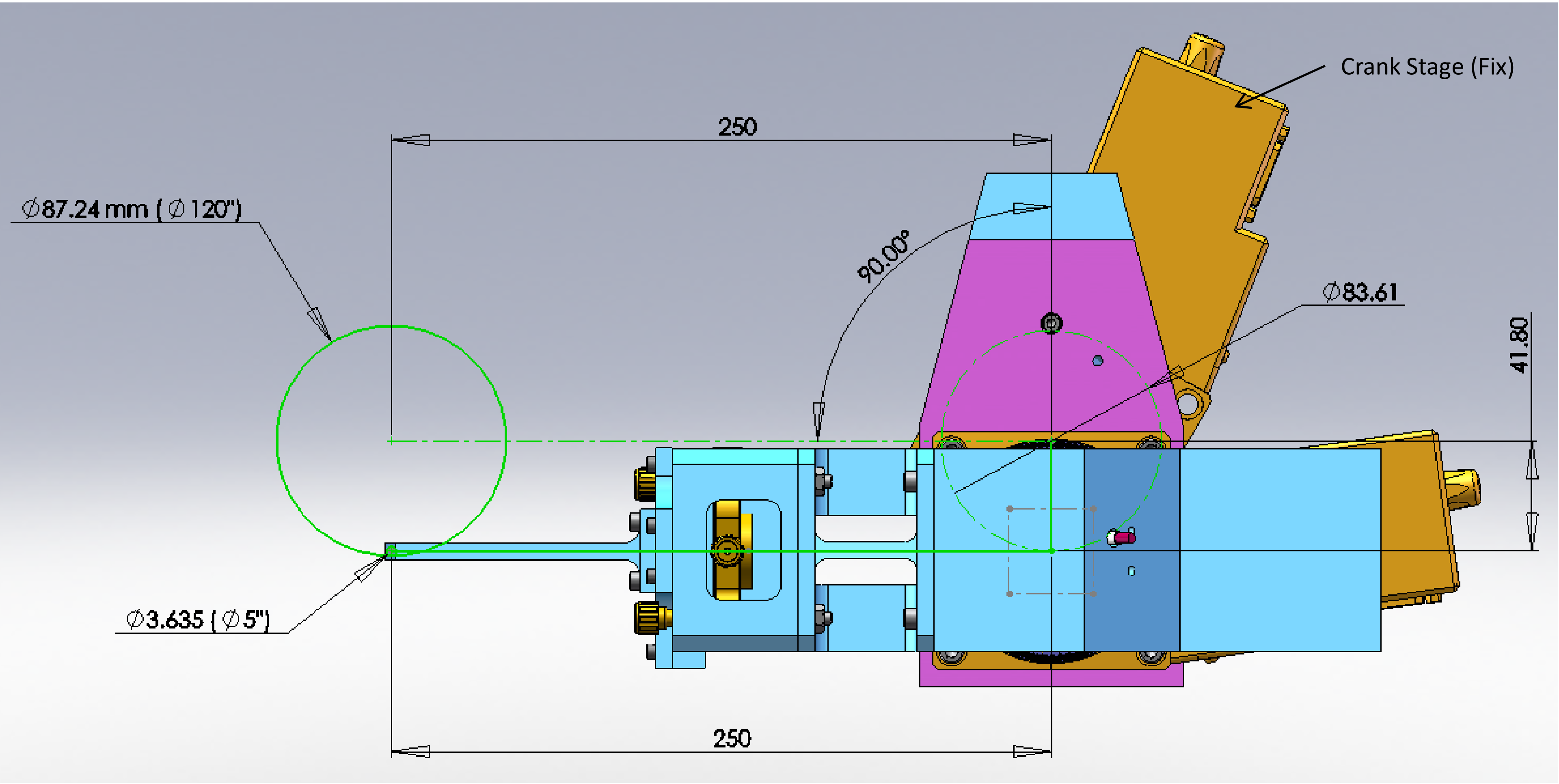
# Preliminary Design With Newport Stages



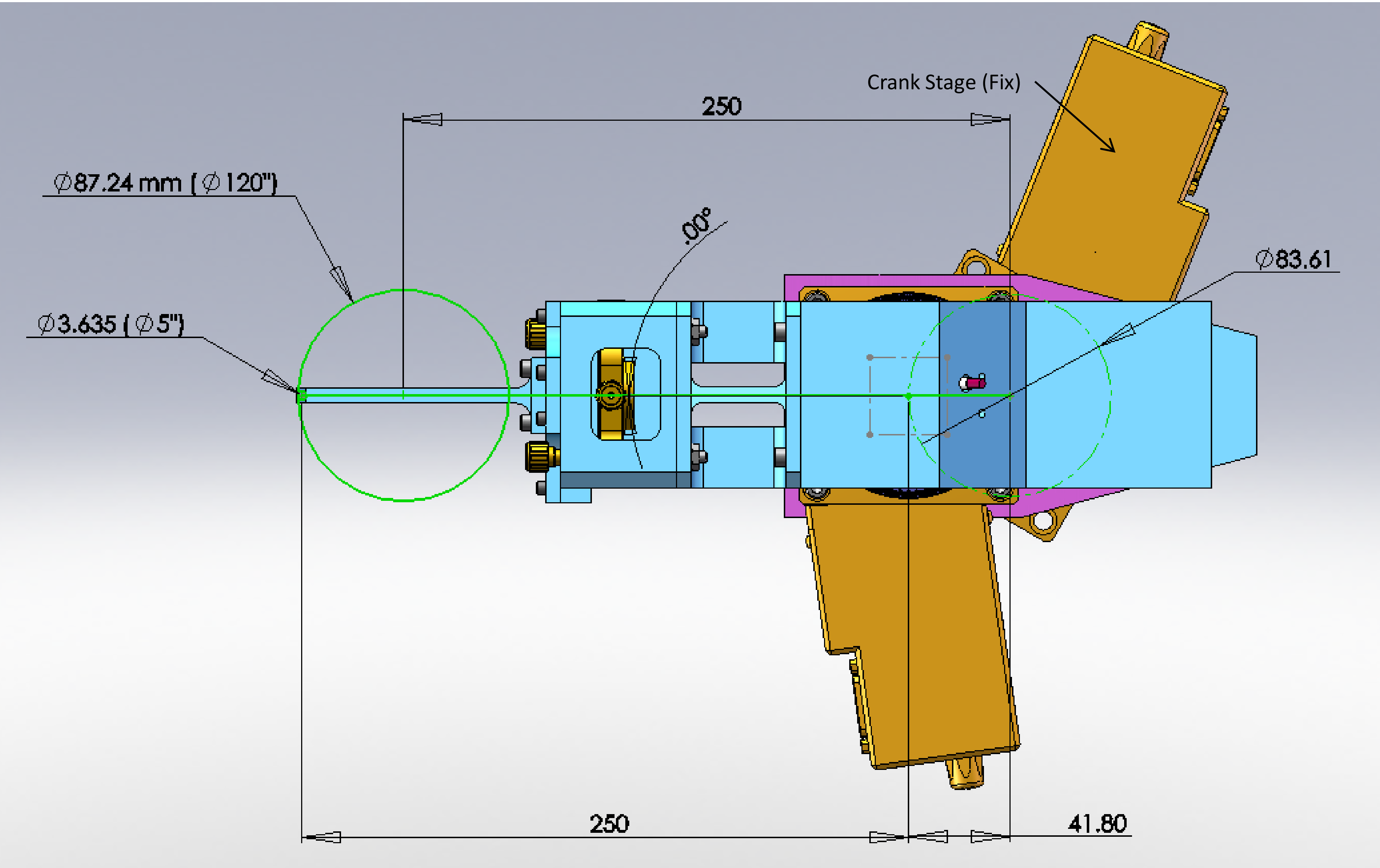
# Crank & Lever Motor @ 0° : Probe at 0° (Probe Fully Retracted)



Crank @ 90° CW & Lever Motor @ 90° CCW° : Probe  at 90° CW

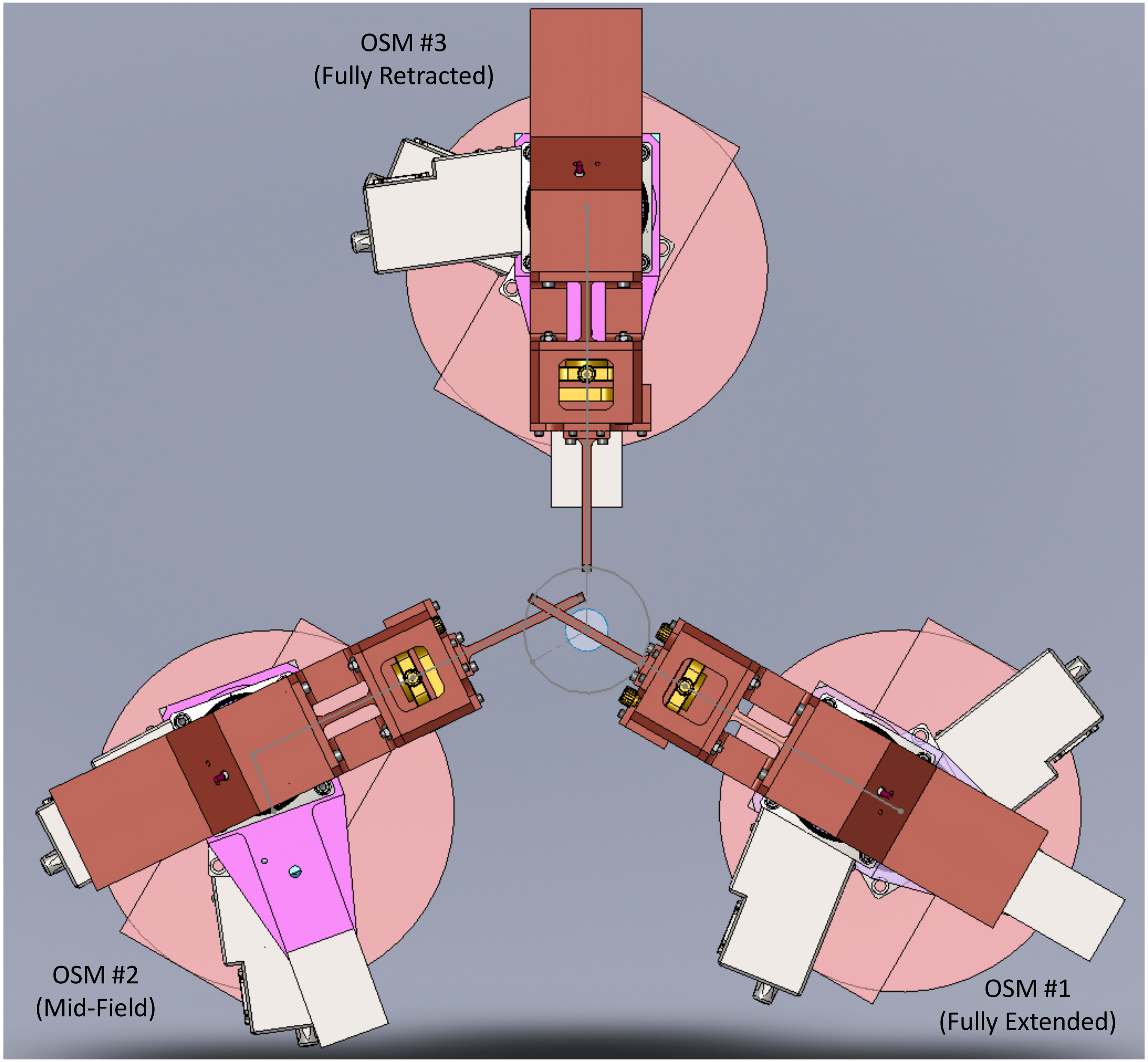


# Crank @ 180° CW & Lever Motor @ 180° CCW° : Probe  Fully Extended

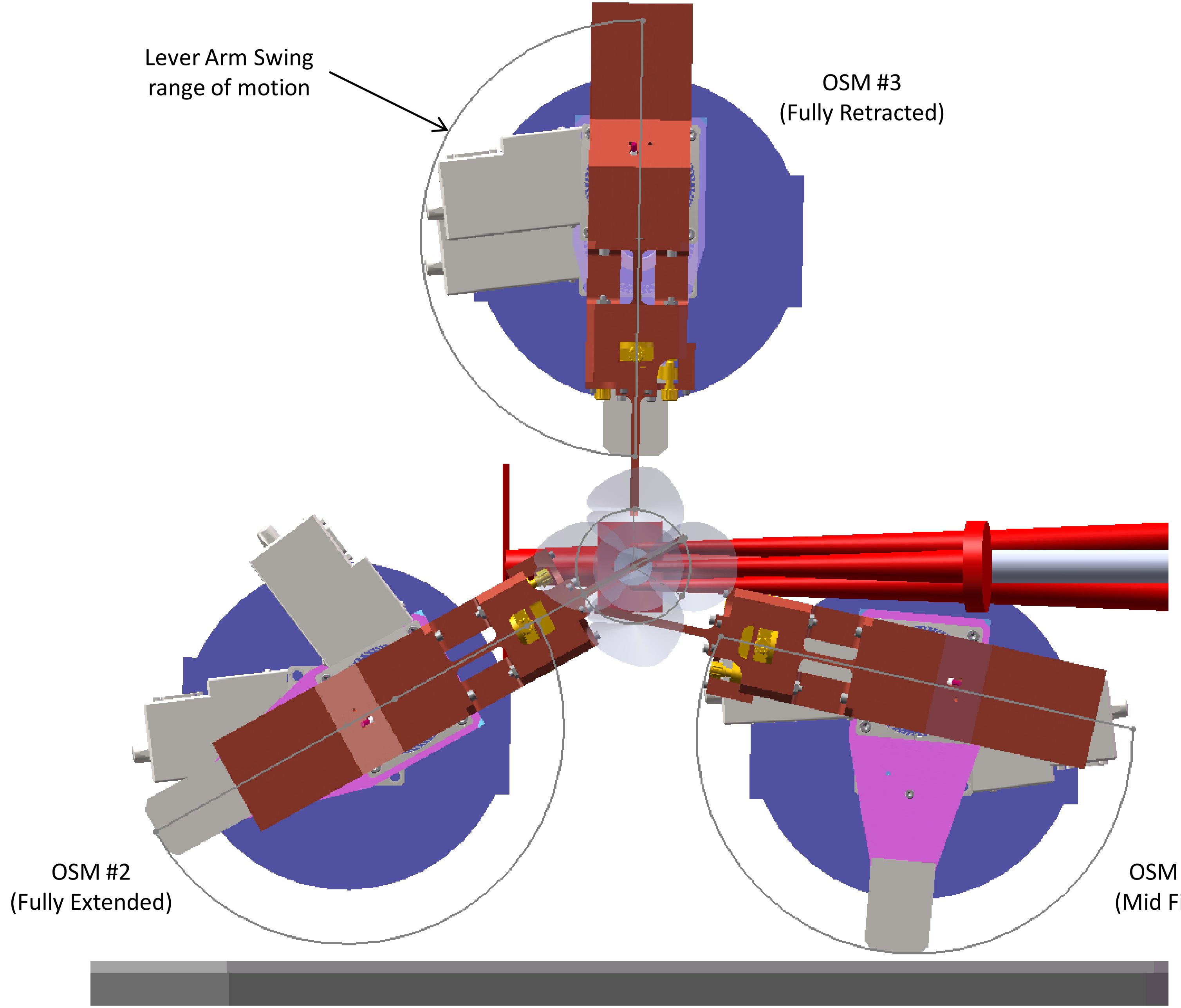



Conclusion:
The whole 120” field can be covered using  180° Rotation for each stages!...

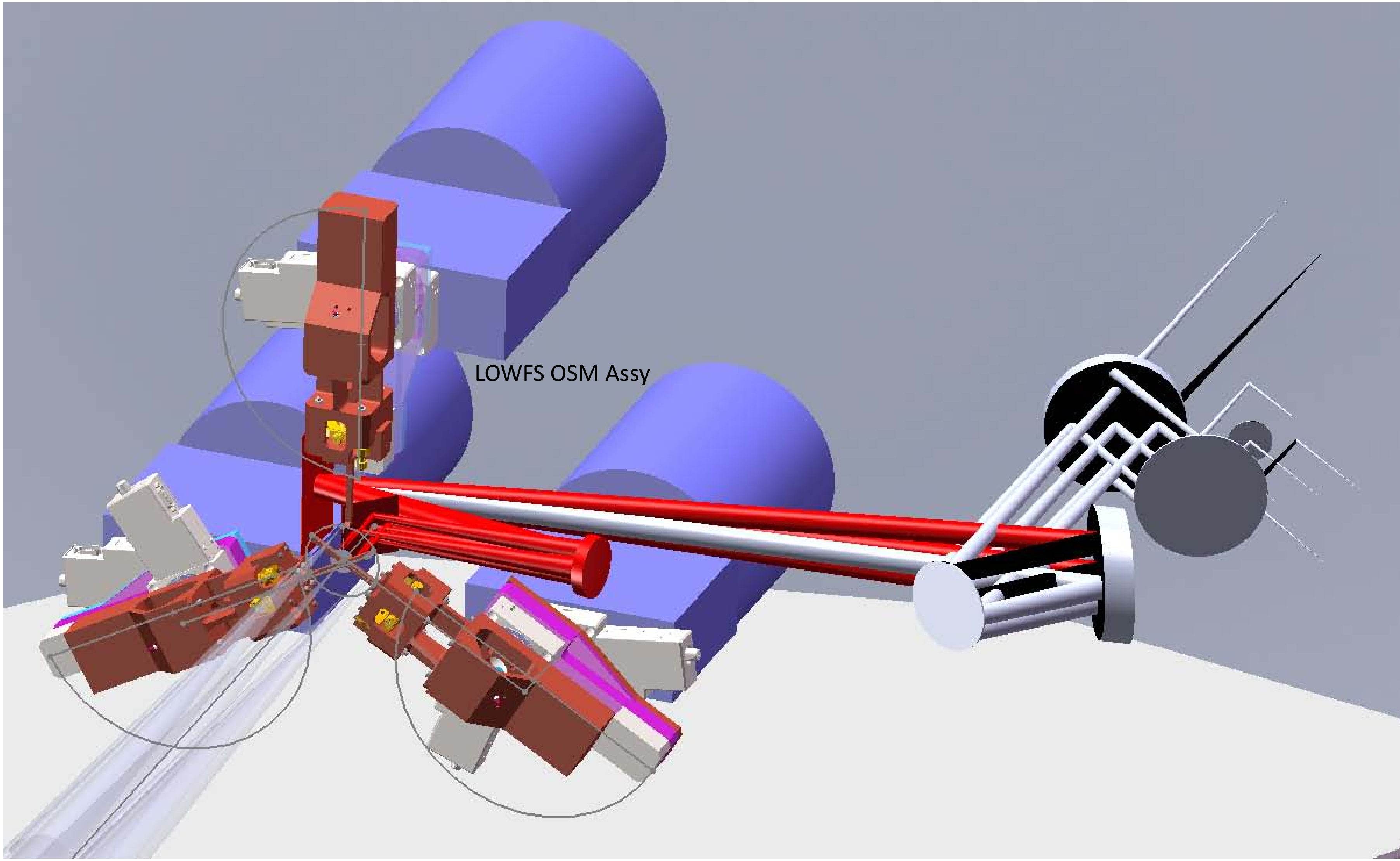
# LOWFS OSM Assy shown at various probe position



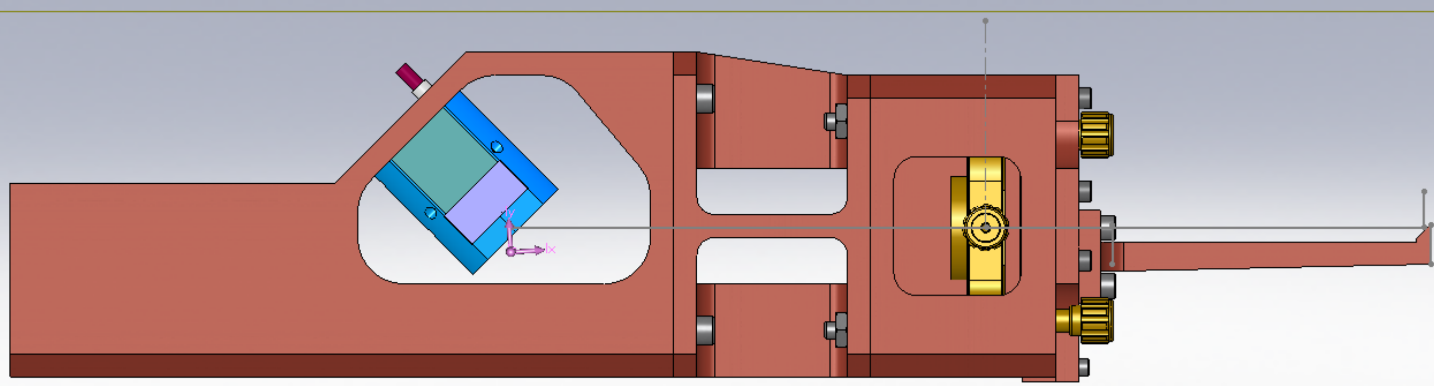
# LOWFS OSM Assy shown at various probe position

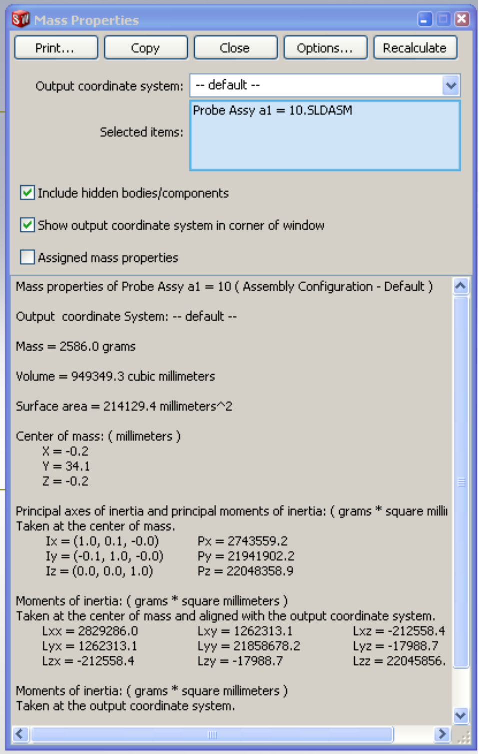


# LOWFS OSM Assy



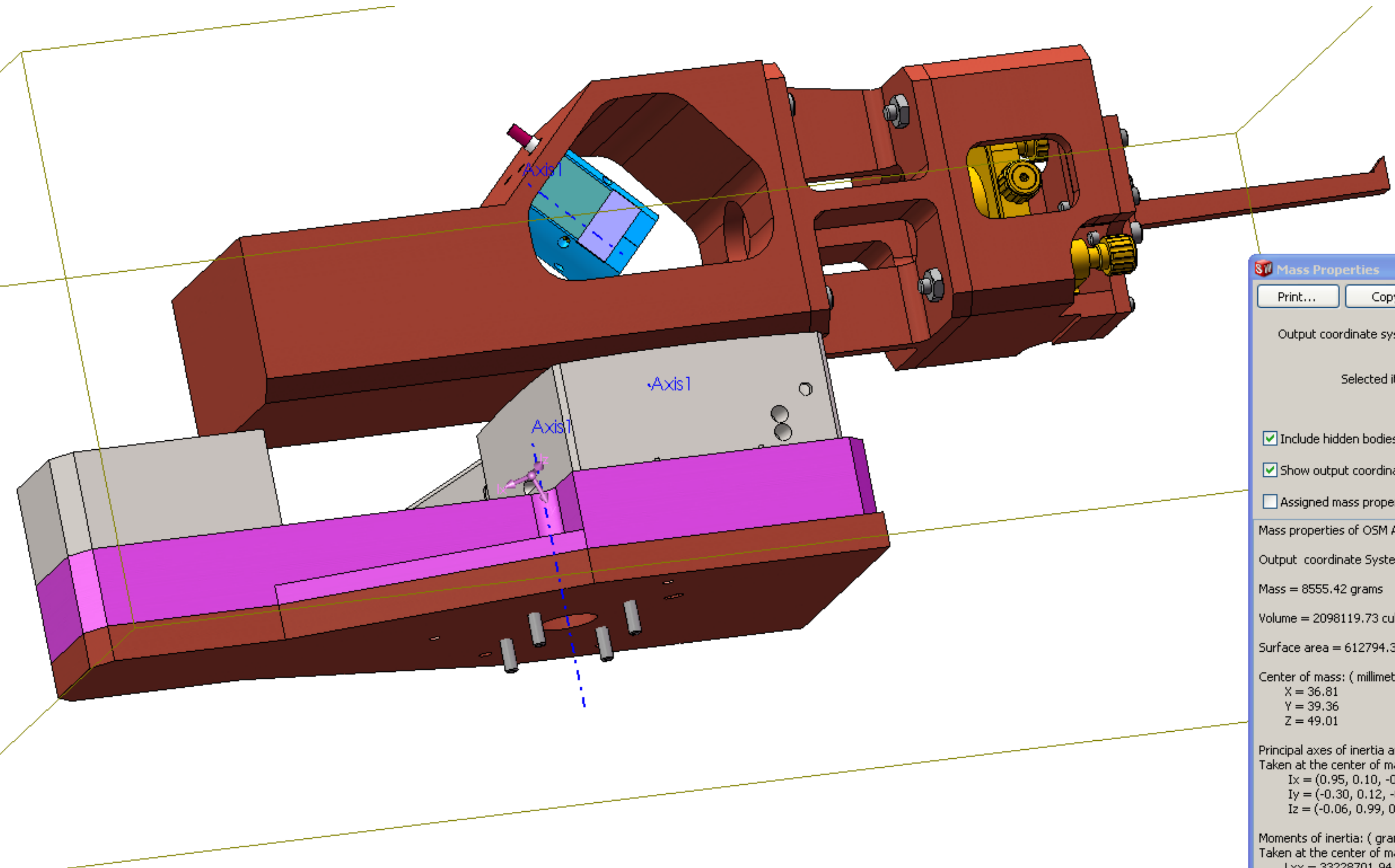
# Lever Arm CG Location

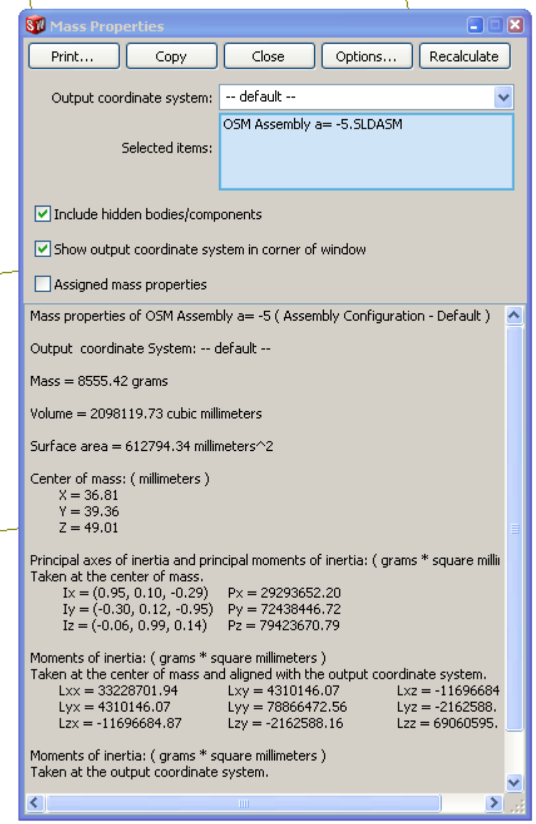





The Lever Arm Assembly shall be designed to locate its CG as close as possible to the Lever Motor Axis ϕ
Balancing the Lever Arm about its CG will facilitate the Lever motor control and stability at full stop.

# Crank Arm Assy CG Location

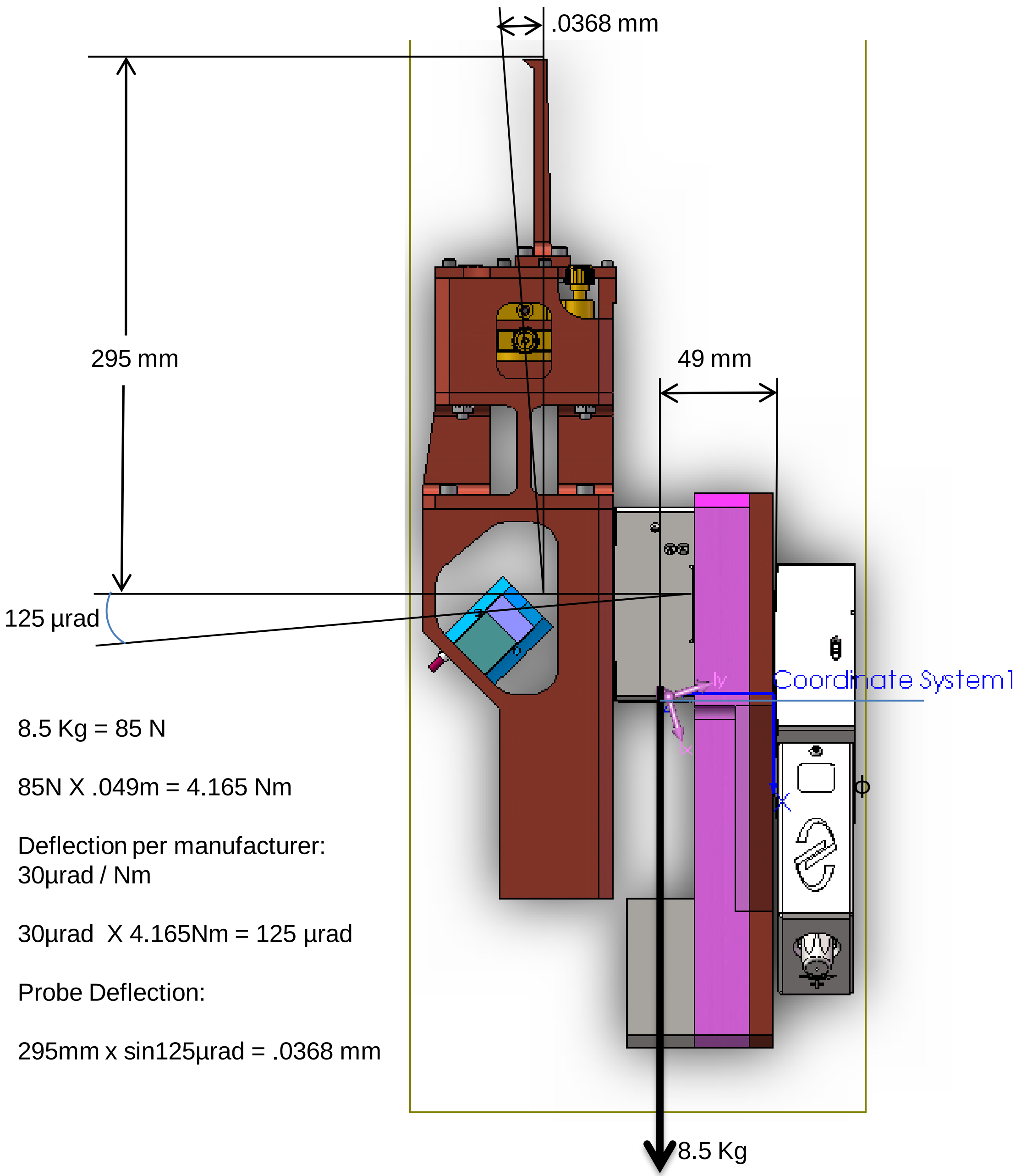



The Crank Arm Assembly shall be designed to locate its CG as close as possible to the Crank Motor Axis θ

Balancing the Lever Arm about its CG will facilitate the Crank motor control and stability at full stop.

# Max Cantilever Torque and Deflection




8.5 Kg = 85 N

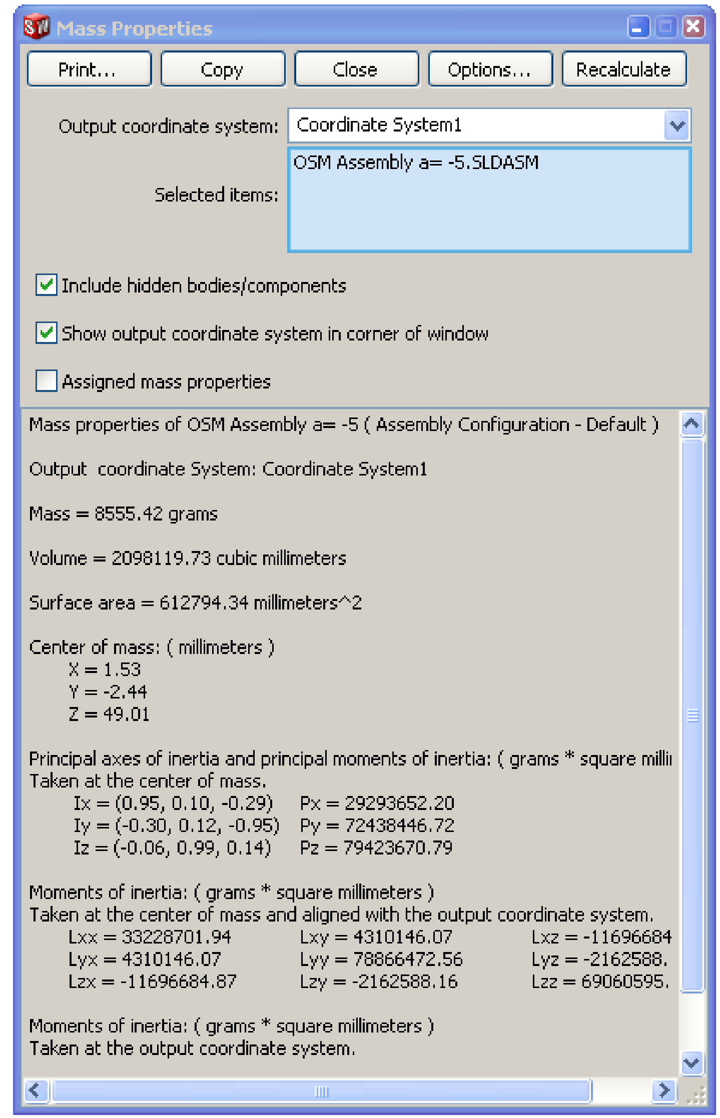
85N X .049m = 4.165 Nm

Deflection per manufacturer:
30µrad / Nm

30µrad X 4.165Nm = 125 µrad

Probe Deflection:

295mm x sin125µrad = .0368 mm



# 5. Servo Motors Vs Stepper Motors

| **Motion Characteristics** | **Servo Motors** | **Stepper Motors** |
|---|---|---|
| **High Torque, Low Speed** | Can be considered if cost/ complexity is not an issue. | Continuous duty applications requiring high torque and low speed. |
| **High Torque and high speed (>2000 rpm)** | Continuous duty applications requiring high torque and high speed.<br>DC servomotor can deliver greater continuous shaft power at high speeds compared to steppers.<br>High speed up to 12000 rpm is possible.<br>AC servo motors can handle higher current surges compared to DC servos.<br>Can get lot stronger AC servo compared to either DC servo or DC stepper. | If speeds are less than 2000 rpm stepper may be economical.<br>Stepper becomes bulky at high torque. |
| **Short, Rapid Repetitive Moves** | Use servo if need high dynamic requirements. | Stepper will offer more economic solution when requirements are more modest. |
| **Positioning Applications** | Servo can handle effectively when load is mostly inertia instead of friction. The ability to overdrive servo motor in intermittent duty allows a smaller motor to be used. **If positioning is critical in micron level use servo.** | Use stepper motor if torque is lower than 500 oz-in, less 2000 rpm, low to medium acceleration rates. |
| **Applications in Hazardous Environments** | Use brushless servo motor. | Use step motor. |
| **Low Speed, High Smoothness** | **Use DC servo**. | Use microstepping. |
| **Control Method** | **Closed loop**. | Preferred to be used in open loop applications. |

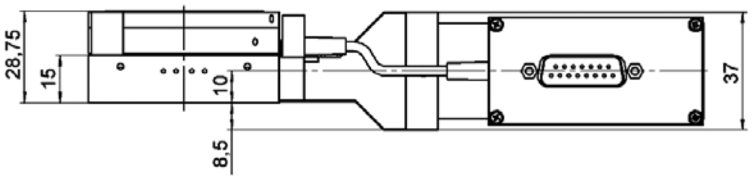
# 6. Potential Lever Motor

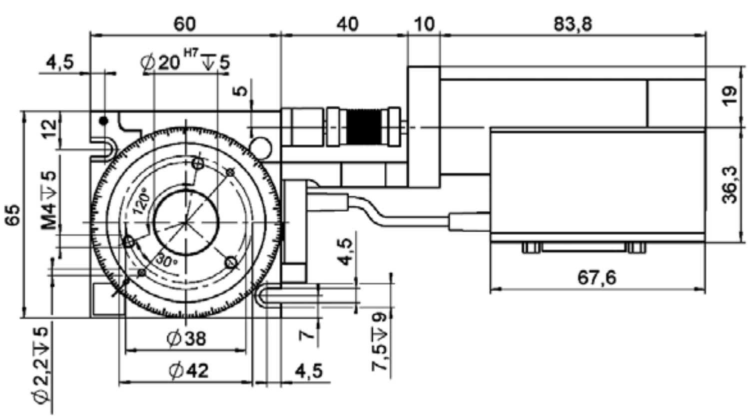
***PI M-037.DG Rotation stage***

M-037 rotation stages are equipped with ultra-precise worm gear drives allowing unlimited rotation in either direction.
An integrated spring preload eliminates backlash.
Double-row ball bearings allow zero backlash, high load capacity and extremely low wobble.

Model M-037.DG is closed-loop DC motors with shaft-mounted position encoders and precision gearheads providing 3.5 µrad at a design resolution of 0.6 µrad.

Model M-037.2S models feature a cost-effective directdrive, 2-phase stepper motor, providing very smooth operation and a resolution of 5.45 µrad at a minimum incremental motion of 21 µm.




**Technical Data**

| Model | M-037.00 | M-037.DG | M-037.PD | M-037.2S | |
|---|---|---|---|---|---|
| Active axes | Rotation | Rotation | Rotation | Rotation | |
| **Motion and positioning** | | | | | |
| Rotation range | >360 | >360 | >360 | >360 | ° |
| Integrated sensor | – | Rotary encoder | Rotary encoder | – | |
| Sensor resolution | – | 2000 | 4000 | – | cts./rev. |
| Design resolution | – | 0.59 (34 x 10⁻⁶) | 8.75 (0.0005) | 5.45* (0.00031) | µrad (°) |
| Min. incremental motion | – | 3.5 | 27 | 21 | µrad |
| Backlash | – | 200 | 200 | 200 | µrad |
| Unidirectional repeatability | – | 30 | 30 | 30 | µrad |
| Wobble | <150 | <150 | <150 | <150 | µrad |
| Max. velocity | – | 6 | 45 | 10 | °/s |
| **Mechanical properties** | | | | | |
| Worm gear ratio | 180:1 | 180:1 | 180:1 | 180:1 | |
| Gear ratio | – | (28/12)⁴ ≈ 29.6:1 | – | – | |
| Motor resolution | – | – | – | 6400* | steps/rev. |
| Load capacity/axial force, self-locking | ±300 | ±300 | ±300 | ±300 | N |
| Max. torque ($\theta_X$, $\theta_Y$) | ±3 | ±3 | ±3 | ±3 | Nm |
| Max. torque clockwise ($\theta_Z$) | 1 | 1 | 1 | 1 | Nm |
| Max. torque counter clockwise ($\theta_Z$) | 0.5 | 0.5 | 0.5 | 0.5 | Nm |
| **Drive properties** | | | | | |
| Motor type | – | DC motor, gearhead | ActiveDrive™ DC Motor | 2-phase stepper motor* | |
| Operating voltage | – | 0 to ±12 | 24 (PWM) | 24 | V |
| Electrical power | – | 3 | 30 | | W |
| Reference switch | – | Hall-effect | Hall-effect | Hall-effect | |
| **Miscellaneous** | | | | | |
| Operating temperature range | -20 to +65 | -20 to +65 | -20 to +65 | -20 to +65 | °C |
| Material | Aluminum | Aluminum | Aluminum | Aluminum | |
| Mass | 0.3 | 0.65 | 0.62 | 0.64 | kg |
| Recommended controller/driver | – | C-863 (single-axis) C-843 PCI-Karte (for up to 4 axes) | C-863 (single-axis, p. 4-114) C-843 PCI-Karte (p. 4-120) (for up to 4 axes) | C-663 (single-axis, p. 4-112) | |

incl. motor cable, 3 m, sub-D connector 15-pin
*2-phase stepper motor, 24 V chopper voltage, max. 0.8 A/phase, 400 full steps/rev., motor resolution with C-663 stepper motor controller


M-037.DG rotation stage with DC Motor and gearhead

# 7. Potential Crank Motor

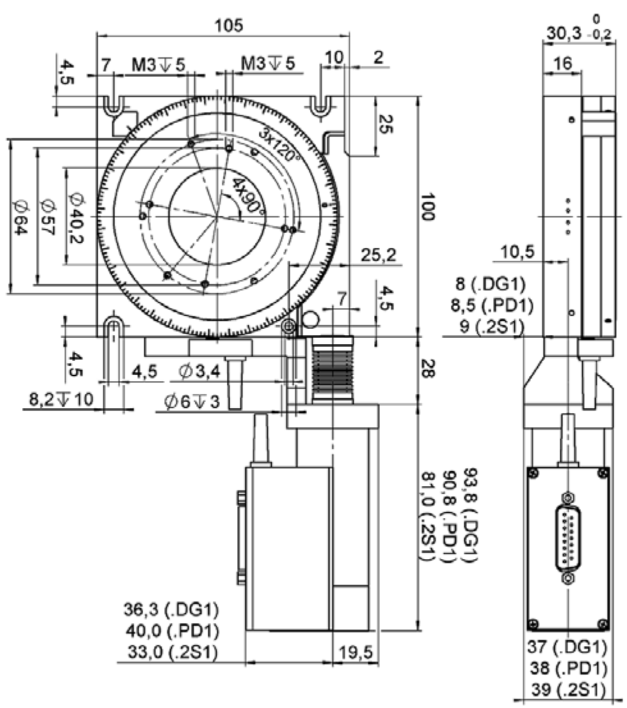
## *PI M-038.DG Rotation stage*

Model M-038.DG1 equipped with a closed-loop DC motor with shaft-mounted position encoder and precision gearhead providing minimum incremental motion of 3.5 µrad at a design resolution of 0.6 µrad.

Model M-038.2S1 models feature a cost-effective directdrive, 2-phase stepper motor, providing very smooth operation and a resolution of 5.45 µrad at a minimum incremental motion of 21 µm.

**ActiveDrive™**

Model M-038.PD is equipped with the highly efficient Active Drive™ direct drive and reaches velocities up to 45°/s. The ActiveDrive™ design, developed by PI, features a high-efficiency PWM (pulse width modulation) servo-amplifier mounted side-by-side with the DC motor and offers several advantages: Increased efficiency, by eliminating power losses between the amplifier and motor. Reduced cost of ownership and improved reliability, because no external driver is required Elimination of PWM amplifier noise radiation, by mounting the amplifier and motor together in a single, electrically shielded case




**Technical Data**

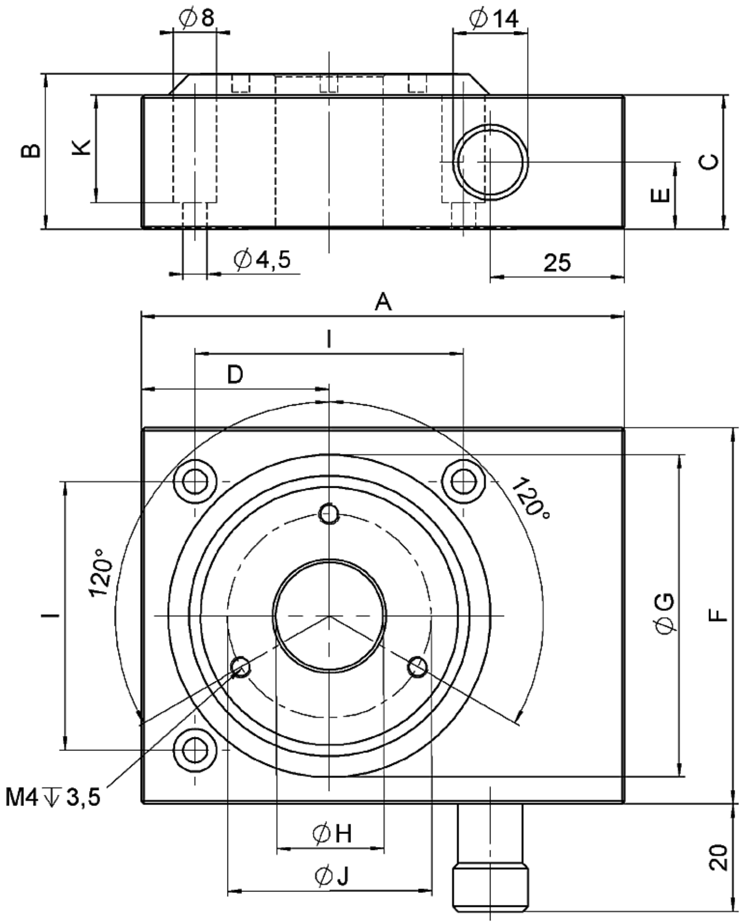
| Model | M-038.001 | M-038.DG1 | M-038.PD1 | M-038.2S1 | Units |
|---|---|---|---|---|---|
| Active axes | Rotation | Rotation | Rotation | Rotation | |
| **Motion and positioning** | | | | | |
| Rotation range | >360° | >360° | >360° | >360° | |
| Integrated sensor | – | Rotary encoder | Rotary encoder | – | |
| Sensor resolution | – | 2000 | 4000 | – | steps/rev. |
| Design resolution | – | 0.60 (35 x 10⁻⁶) | 8.95 (0.0005) | 5.58* (0.00032) | µrad (°) |
| Min. incremental motion | – | 3.5 | 27 | 21 | µrad |
| Backlash | – | 200 | 200 | 200 | µrad |
| Unidirectional repeatability | – | 20 | 20 | 20 | µrad |
| Wobble | <75 | <75 | <75 | <75 | µrad |
| Max. velocity | – | 6 | 90 | 10 | °/s |
| **Mechanical properties** | | | | | |
| Worm gear ratio | 176:1 | 176:1 | 176:1 | 176:1 | |
| Gear ratio | – | 2401:81 ≈ 29.6:1 | – | – | |
| Motor resolution | – | – | – | 6400* | steps/rev. |
| Max. load/axial force | ±400 | ±400 | ±400 | ±400 | N |
| Maximum torque ($\theta_X$, $\theta_Y$) | ±6 | ±6 | ±6 | ±6 | |
| Maximum torque CW** | 2 | 2 | 2 | 2 | Nm |
| Maximum torque CCW** | 0.8 | 0.8 | 0.8 | 0.8 | Nm |
| **Drive properties** | | | | | |
| Motor type | – | DC Motor, gearhead | ActiveDrive™ DC Motor | 2-phase stepper motor* | |
| Electrical power | – | 3 | 30 | | W |
| Reference switch | – | Hall-effect | Hall-effect | Hall-effect | |
| **Miscellaneous** | | | | | |
| Operating voltage | – | 12 V differential | 24 (PWM) | 24 | V |
| Operating temperature range | -20 to +65 | -20 to +65 | -20 to +65 | -20 to +65 | °C |
| Material | Aluminum | Aluminum | Aluminum | Aluminum | |
| Mass | 0.9 | 1.25 | 1.35 | 1.25 | kg |
| Recommended controller/driver | | C-863 (single-axis) C-843 PCI board (for up to 4 axes) | C-863 (single-axis, p. 4-114) C-843 PCI board (p. 4-120) (for up to 4 axes) | C-663 (single-axis, p. 4-112) | |

*2-phase stepper motor, 24 V chopper voltage, max. 0.8 A/phase, 400 full steps/rev., motor resolution with C-663 stepper motor controller
**CW: clockwise; CCW: counter-clockwise


M-038.PD1 Rotation Stage

Custom M-038 with folded drive

## *Other Possible Crank motor: M-06X.DG Rotation stage*




| Dimensions | M-060.M0 | M-061.M0 | M-062.M0 |
|---|---|---|---|
| A | 90 | 130 | 150 |
| B | 29 | 34 | 42 |
| C | 25 | 30 | 38 |
| D | 35 | 55 | 65 |
| E | 12,5 | 15 | 21,5 |
| F | 70 | 110 | 130 |
| G | 60 | 100 | 120 |
| H | 20 | 35 | 45 |
| I | 50 | 90 | 110 |
| J | 38 | 50 | 60 |
| K | 20 | 20 | 28 |

**Technical Data**

| Model | M-060.M0 / M-061.M0 / M-062.M0 | M-060.PD / M-061.PD / M-062.PD | M-060.DG / M-061.DG / M-062.DG | M-060.2S / M-061.2S / M-062.2S | Units |
|---|---|---|---|---|---|
| Active axes | Rotation | Rotation | Rotation | Rotation | |
| **Motion and positioning** | | | | | |
| Rotation range | >360 | >360 | >360 | >360 | ° |
| Integrated sensor | – | Rotary encoder | Rotary encoder | | |
| Sensor resolution | – | 4000 | 2000 | | Cts./rev. |
| Design resolution | – | 32 (0.0018) / 17.5 (0.001) / 15 (0.0008) | 2.1 (0.00012) / 1.2 (6.9 x $10^{-5}$) / 0.96 (5.5x$10^{-5}$) | 19.7 (0.0011) / 10.9 (0.00063) / 8.9 (0.00051)* | µrad (°) |
| Min. incremental motion | – | 32 / 17.5 / 15 | 6.3 / 6 / 5 | 40 / 20 / 18* | µrad |
| Backlash | – | 200 / 200 / 240 | 200 / 200 / 240 | 200 / 200 / 240 | µrad |
| Unidirectional repeatability | – | 50 / 50 / 60 | 50 / 50 / 60 | 50 / 50 / 60 | µrad |
| Max. velocity | – | 90 | 16 / 9 / 7.3 | 36 / 20 / 16 | °/s |
| **Mechanical properties** | | | | | |
| Worm gear ratio | 50:1 / 90:1 / 110:1 | 50:1 / 90:1 / 110:1 | 50:1 / 90:1 / 110:1 | 50:1 / 90:1 / 110:1 | |
| Gear ratio | – | – | $(28/12)^4$ :1 ≈ 29.6:1 | – | |
| Motor resolution | – | – | – | 6400* | steps/rev. |
| Axial force | ±500 / ±550 / ±650 | ±500 / ±550 / ±650 | ±500 / ±550 / ±650 | ±500 / ±550 / ±650 | N |
| Max. torque $\theta_X$, $\theta_Y$ | ±6 / ±6 / ±7 | ±6 / ±6 / ±7 | ±6 / ±6 / ±7 | ±6 / ±6 / ±7 | Nm |
| Max. torque $\theta_Z$ | ±4 / ±6 / ±8 | ±4 / ±6 / ±8 | ±4 / ±6 / ±8 | ±4 / ±6 / ±8 | Nm |
| **Drive properties** | | | | | |
| Motor type | – | ActiveDrive™ DC-Motor | DC-Motor, gearhead | 2-phase Stepper-Motor** | |
| Operating voltage | – | 24 (PWM) | 12 differential | 24 | V |
| Electrical power | – | 30 | 3 | – | |
| Reference switch | Hall-effect | Hall-effect | Hall-effect | Hall-effect | |
| **Miscellaneous** | | | | | |
| Operating temperature range | -20 to +65 | -20 to +65 | -20 to +65 | -20 to +65 | °C |
| Material | Aluminum | Aluminum | Aluminum | Aluminum | |
| Mass | 0.42 / 1.36 / 2.24 | 0.94 / 1.88 / 2.76 | 0.94 / 1.88 / 2.76 | 0.96 / 1.9 / 2.78 | kg |
| Recommended controller/driver | | C-863 single-axis C-843 PCI board, for up to 4 axes | C-863 single-axis (p. 4-114) C-843 PCI board (p. 4-120), for up to 4 axes | C-663 single-axis (p. 4-112) | |

*with C-663 stepper-motor controller
**2-phase stepper-motor, 24 V chopper voltage, max. 0.8 A/phase, 400 full steps/rev

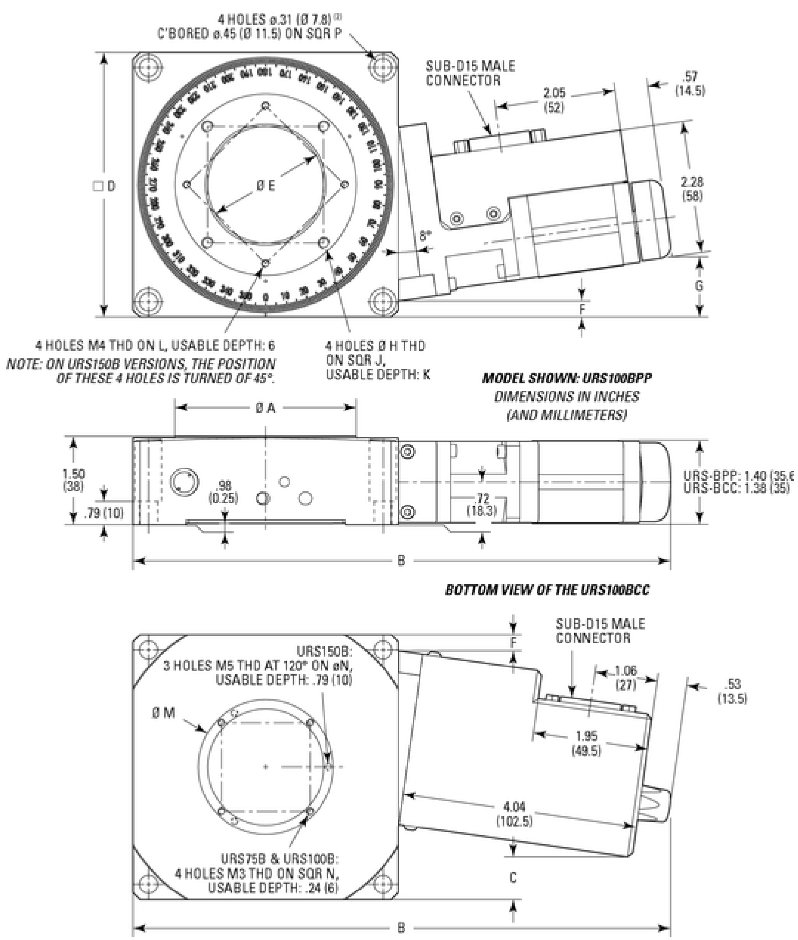
# 8. Potential Crank & Lever Motor

## Newport URS Series Precision Rotation Stages

**Dimensions**

Dimensions in inches (millimeters)

**MODEL URS100B**




| | A | B | C | D | E | F | G | H | J | K | L | M | N | P |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| URS75B | 1.97 (50) | 8.19 (208) | -.20(1) (-5)(1) | 3.54 (90) | $1.18^{+.0051}_{0}$ $(30^{+.013}_{0})$ | .08 (2) | .83 (21) | M3 | 1.26 (32) | .24 (6) | – | 1.50 (38) | 1.34 (34) | 2.98 (75.6) |
| URS100B | 3.07 (78) | 9.13 (232) | .71 (18) | 4.49 (114) | $1.97^{+.0063}_{0}$ $(50^{+.016}_{0})$ | .26 (6.5) | 1.02 (26) | M6 | 1.97 (50) | .24 (6) | SQR 1.89 (SQR 48) | 2.28 (58) | 2.13 (54) | 3.97 (100.8) |
| URS150B | 5.18 (131.5) | 11.14 (283) | 2.56 (65) | 6.50 (165) | $3.54^{+.0087}_{0}$ $(90^{+.022}_{0})$ | .41 (10.5) | 1.14 (29) | M6 | 2.95 (75) | .31 (8) | ø4.92 (Ø 125) | 4.13 (105) | 3.86 (98) | 5.91 and 6(2) (150 and 152.4)(2) |

*Notes:*

*(1) The drive box of the URS75BCC exceeds .20 in. (5 mm) from the body.*

*(2) URS150B: 4 slots counterbored.*

**Design Details**

| | |
|---|---|
| Base Material | Hardened steel with aluminum body |
| Bearings | |
| Drive Mechanism | Ground worm gear with self-compensating preload. Additional 1:2.75 drive belt with URS-CC versions (no belt on URS-PP versions) |
| Worm Gear Ratio | 1:90 |
| Feedback | CC: Worm mounted rotary encoder, 8,000 cts/rev, index pulse.<br>PP: None |
| Limit Switches | Two independently adjustable optical limit switches |
| Origin | Optical, fixed at position 0°. Typical 0.0005° repeatability for URS-CC and 0.04° repeatability for URS-PP |
| Manual Adjustment | Via allen wrench at the end of the worm screw. Allen wrench is included. |
| Motor | CC: UE34CC DC servo motor<br>PP: UE34PP Two phase stepper motor, 1 full step = 0.02° |
| Cable | |

**Specifications**

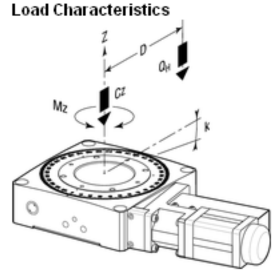
| | PP | | CC | |
|---|---|---|---|---|
| | Typical | Guaranteed | Typical | Guaranteed |
| Travel Range (°) | 360 continuous(1) | | | |
| Resolution (°) | 0.0002(2) | | 0.0005 | |
| Minimum Incremental Motion (°) | 0.0002 | | 0.002 | |
| Uni-directional Repeatability (°) | 0.001 | 0.002 | 0.001 | 0.002 |
| Reversal Value (Hysteresis) (°) | 0.006 | 0.01 | 0.002 | 0.004 |
| Absolute Accuracy (°) | 0.016 | 0.030 | 0.012 | 0.023 |
| Maximum Speed (°/s) | 40 | | 80 | |
| Wobble (µrad) | 20 | 50 | 20 | 50 |
| Eccentricity (µm) | | 3 | | 3 |
| MTBF | 20,000 h at 25% load and with a 30% duty cycle | | | |

1) With disabled limit switches

2) Equal to 1/100 of a full step

See the Motion Control Metrology Primer section (see Motion Control Metrology Primer) for more information on typical and guara

**Load Characteristics**




| | URS75 | URS100 | URS150 |
|---|---|---|---|
| Cz, Normal centered load capacity (N) | 200 | 300 | 300 |
| a, Construction parameter (mm) | 25 | 35 | 55 |
| kα, Transversal compliance (µrad/Nm) | 30 | 10 | 5 |
| Mz, Nominal Torque (Nm) | +/- 0.5 | +/- 1 | +/- 2 |
| Q, Off-center load | Q ≤ Cz / (1 + D/a) | | |
| D, Cantilever distance in mm | | | |
| Weight [lb (kg)] | 3.7 (1.7) | 4.4 (2) | 7.5 (3.4) |

# 9. Comparison between Potential Stages.

| Specifications | URS75BPP Typ. | URS75BPP Guaranteed | URS75BCC Typ. | URS75BCC Guaranteed | M-037.DG | M-038.DG1 |
|---|---|---|---|---|---|---|
| Motor Type | Stepper | | DC servo | | DC servo | DC servo |
| Feedback | None | | Worm mounted encoder | | Shaft mounted encoder | Shaft mounted encoder |
| Worm Gear Ratio | 1:90 | | 1:90 | | 180:1 | 176:1 |
| Sensor Resolution (cts/rev) | None | | 8000 | | 2000 | 2000 |
| Resolution (°) | 0.0002 | | 0.0005 | | 0.00003 | .000003 |
| Minimum Incremental Motion (°) | 0.0002 | | 0.002 | | .0002 | .0002 |
| Uni-directional Repeatability (°) | 0.001 | 0.002 | 0.001 | 0.002 | .0017 | .0011 |
| Reversal Value (Hysteresis) (°) | 0.006 | 0.01 | 0.002 | 0.004 | .01 | .01 |
| Absolute Accuracy (°) | 0.016 | 0.030 | 0.012 | 0.023 | TBD | TBD |
| Maximum Speed (°/s) | 40 | | 80 | | 6 | 6 |
| Wobble (µrad) | 20 | 50 | 20 | 50 | <150 | <75 |
| Eccentricity (µm) | 3 | | 3 | | TBD | TBD |
| Max Axial Load (N) | 200 | | 200 | | 300 | 400 |
| Max CW Torque (CCW) | 0.5 (0.5) | | 0.5 (0.5) | | 1 (0.5) | 2 (0.8) |
| Max Cantilever Torque (Nm) | 5 | | 5 | | 6 | 6 |
| Mass (N) | 17 | | 17 | | 6.5 | 12.5 |
| MTBF at 25% load and with a 30% duty cycle | 20,000 h | | 20,000 h | | TBD | TBD |
| Integrated limit switch | Adjustable | | Adjustable | | No | No |
| Price | $2940 | | $3436 | | $4178 | $4724 |

# Comparison between Potential Stages.

Mass on Lever motor: Tip Tilt Mirror (0.065 Kg) + TT Mirror Housing (0.100 Kg) + Probe Assy (0.120 Kg) + Collimator Assy (0.01 Kg) = 0.295 Kg

Mass on crank motor:

Mass on lever motor +Crank Adaptor (0.100 Kg) + Lever Adaptor (0.100 Kg) + Periscope Assy( 0.015 Kg) + Counterweight (1 Kg) + Lever Motor = 1.215 Kg + Lever Motor

Distance between Crank Motor and center of Mass installed on Crank motor: 40mm

1) Using the PI Motors as follow: M-038.DG1 as Crank Motor and the M-037.DG as the Lever motor:

Mass on Crank motor: 1.215 Kg + 0.65 Kg = 2 Kg (20N)

Cantilever Torque at Crank motor: 0.04m X 20 = 0.8 Nm

2) Using the URS75BCC Newport Motor for both Crank and Lever motor:

Mass on Crank motor: 1.215 Kg + 1.7 Kg = 3 Kg (30N)

Cantilever Torque at Crank motor: 0.04m X 30 = 1.2 Nm

Off Center Load: Q < 200 / (1 + 40/25) = 77 N

CONCLUSION: The Newport URS75BCC is cheaper and faster than the PI Stages and comparatively as accurate.

The Newport URS75BCC is a bigger stage than the PI Stage: The Arm length will have to be proportionally longer.

Lever Arm + Crank Arm + Probe = Fov + Separation + Crank Arm

Lever Arm + 1.8175 = 87.24 + 63.5

➔ Lever Arm = 148.9225 mm

Lever Arm - Crank Arm = Separation + Crank Arm + Probe

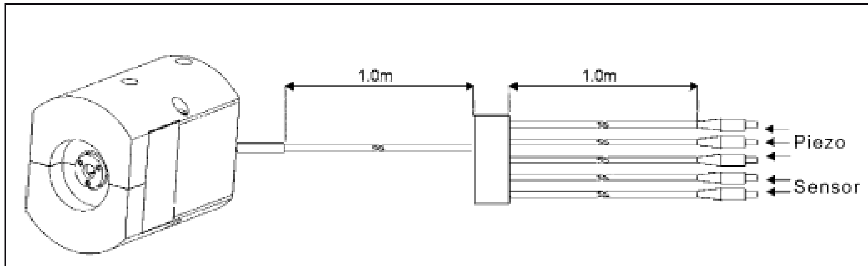
148.9225 - Crank Arm = 63.5 + Crank Arm + 1.8175

➔ Crank Arm = 41.8025 mm

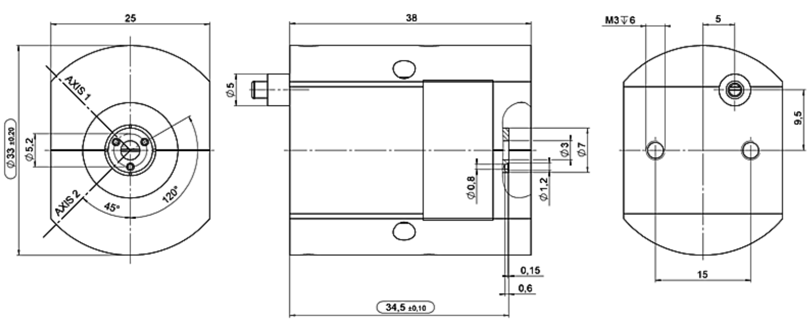
Needs Update

# 10. Potential Tip / Tilt Mirror

PI S-334 Miniature Piezo Fast Steering Tip/Tilt-Mirror
up to 120 mrad Deflection




S-334.2SL cable configuration

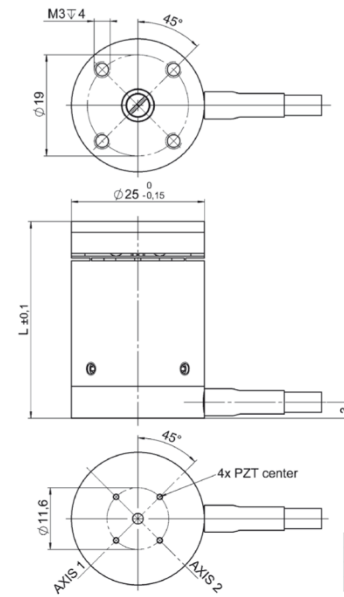


**Technical Data**

| Model | S-334.2SL | S-334.2SD | Units | Tolerance |
|---|---|---|---|---|
| Active Axes | $\theta_X$, $\theta_Y$ | $\theta_X$, $\theta_Y$ | | |
| **Motion and positioning** | | | | |
| Integrated sensor | SGS | SGS | | |
| *Open-loop tilt angle at -20 to +120 V | 60 | 60 | mrad | min. (+20 %/-0 %) |
| *Closed-loop tilt angle | 50 | 50 | mrad | |
| Open-loop resolution | 0.5 | 0.5 | µrad | typ. |
| Closed-loop resolution | 5 | 5 | µrad | typ. |
| Linearity | 0.05 | 0.05 | % | typ. |
| Repeatability | 5 | 5 | µrad | typ. |
| **Mechanical properties** | | | | |
| Resonant frequency under load (with standard mirrors) | 1.0 | 1.0 | kHz | ±20 % |
| Resonant frequency with 12.5 mm diam. x 2 mm glass mirror | 0.8 | 0.8 | kHz | ±20 % |
| Load capacity | 0.2 | 0.2 | N | Max. |
| Distance of pivot point to platform surface | 6 | 6 | mm | ±1 mm |
| Platform moment of inertia | 1530 | 1530 | g x mm² | ±20 % |
| Standard mirror (mounted) | diameter: 10 mm, thickness: 2 mm, BK7, λ/5, R > 98 % (λ = 500 nm to 2 µm) | diameter: 10 mm, thickness: 2 mm, BK7, λ/5, R > 98 % (λ = 500 nm to 2 µm) | | |
| **Drive properties** | | | | |
| Ceramic type | PICMA® P-885 | PICMA® P-885 | | |
| Electrical capacitance | 6 | 6 | µF | ±20 % |
| **Miscellaneous** | | | | |
| Operating temperature range | -20 to 80 | -20 to 80 | °C | |
| Material casing | Titanium | Titanium | | |
| Mass | 0.065 | 0.065 | kg | ±5 % |
| Cable length | 2 | 2 | m | ±10 mm |
| Sensor / voltage connection | LEMO connector | 25-pin sub-D connector | | |
| Recommended controller / amplifier | Modular piezo controller system E-500 (p. 2-144) with amplifier module E-503.00S (three channels) (p. 2-146) or 1 x E-505.00S and 2 x E-505 (high speed applications) (p. 2-147) and E-509 servo controller (p. 2-152) Open-loop: E-663 three channel amplifier (p. 2-136) | E-616 controller for tip/tilt mirror systems (p. 2-132) | | |

# Potential Tip / Tilt Mirror

## PI S-330-2XX Miniature Piezo Fast Steering Tip/Tilt-Mirror


| | L |
|---|---|
| S-330.2xx | 37 |
| S-330.4xx | 55 |
| S-330.8xx | 91 |

**Technical Data**

| Model | S-330.2SL | S-330.4SL | S-330.8SL | S-330.2SD<br>S-330.4SD<br>S-330.8SD | S-330.20L<br>S-330.40L<br>S-330.80L | Units | Tolerance |
|---|---|---|---|---|---|---|---|
| Active axes | $\Theta_X, \Theta_Y$ | $\Theta_X, \Theta_Y$ | $\Theta_X, \Theta_Y$ | $\Theta_X, \Theta_Y$ | $\Theta_X, \Theta_Y$ | | |
| **Motion and positioning** | | | | | | | |
| Integrated sensor | SGS | SGS | SGS | SGS | – | | |
| Open-loop tip/tilt angle, -20 to +120 V | 3.5 | 7 | 15 | as SL version | as SL version | mrad | min. |
| Closed-loop tip/tilt angle | 2 | 5 | 10 | as SL version | – | mrad | |
| Open-loop tip/tilt angle resolution | 0.02 | 0.1 | 0.2 | as SL version | as SL version | µrad | typ. |
| Closed-loop tip/tilt resolution | 0.05 | 0.25 | 0.5 | as SL version | – | µrad | typ. |
| Linearity in $\Theta_X, \Theta_Y$ | 0.1 | 0.2 | 0.25 | as SL version | – | % | typ. |
| Repeatability $\Theta_X, \Theta_Y$ | 0.15 | 0.5 | 1 | as SL version | – | µrad | typ. |
| **Mechanical properties** | | | | | | | |
| Unloaded resonant frequency ($\Theta_X, \Theta_Y$) | 3.7 | 3.3 | 3.1 | as SL version | as SL version | kHz | ±20% |
| Resonant frequency loaded in $\Theta_X, \Theta_Y$ (with 25 x 8 mm glass mirror) | 2.6 | 1.6 | 1.0 | as SL version | as SL version | kHz | ±20% |
| Distance of pivot point to platform surface | 6 | 6 | 6 | 6 | 6 | mm | ±1 mm |
| Platform moment of inertia | 1530 | 1530 | 1530 | 1530 | 1530 | g x mm² | ±20% |
| **Drive properties** | | | | | | | |
| Ceramic type | PICMA® | PICMA® | PICMA® | PICMA® | PICMA® | | |
| Electrical capacitance | 3/axis | 6/axis | 12.5/axis | as SL | as SL | µF | ±20% |
| Dynamic operating current coefficient | 0.22/axis | 0.4/axis | 0.8/axis | as SL | as SL | µA/(Hz • mrad) | ±20% |
| **Miscellaneous** | | | | | | | |
| Operating temperature range | -20 to 80 | -20 to 80 | -20 to 80 | -20 to 80 | -20 to 80 | °C | |
| Material case | Stainless steel | Stainless steel | Stainless steel | Stainless steel | Stainless steel | | |
| Material platform | Invar | Invar | Invar | Invar | Invar | | |
| Mass | 0.2 | 0.38 | 0.7 | as SL version | as SL version | kg | ±5% |
| Cable length | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | m | ±10 mm |
| Sensor / voltage connection | LEMO | LEMO | LEMO | Sub-D connector | LEMO | | |

Recommended controller / amplifier
Versions with LEMO connector: modular piezo controller system E-500 (p. 2-142) with amplifier module E-503.00S (three channels) (p. 2-146)
or 1 x E-505.00S and 2 x E-505 (high speed applications) (p. 2-147) and E-509 controller (p. 2-152) (optional)
Open-loop: E-663 three channel amplifier (p. 2-136)
Versions with Sub-D connectors: E-616 servo controller for tip/tilt mirror systems (p. 2-132)

**Ordering Information**

**S-330.2SL**
High-Dynamics Piezo Tip/Tilt Platform, 2 mrad, SGS, LEMO Connector

**S-330.2SD**
High-Dynamics Piezo Tip/Tilt Platform, 2 mrad, SGS, Sub-D Connector

**S-330.20L**
High-Dynamics Piezo Tip/Tilt Platform, 2 mrad, Open-Loop, LEMO Connector

**S-330.4SL**
High-Dynamics Piezo Tip/Tilt Platform, 5 mrad, SGS, LEMO Connector

**S-330.4SD**
High-Dynamics Piezo Tip/Tilt Platform, 5 mrad, SGS, Sub-D Connector

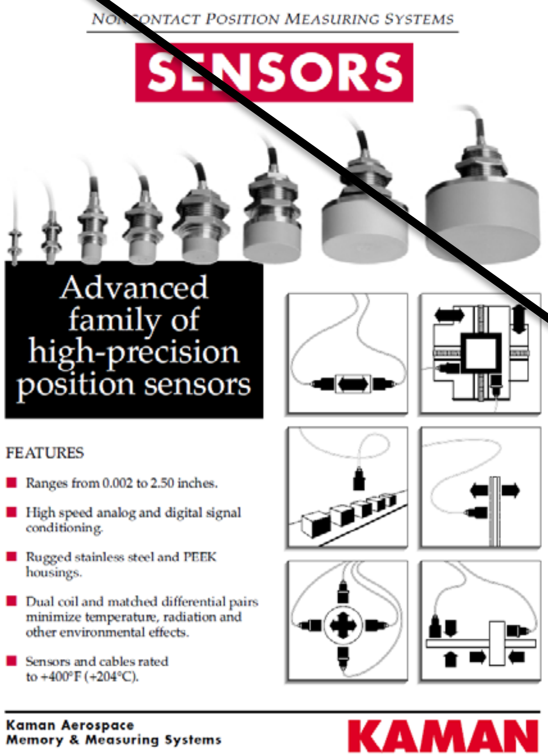
**S-330.40L**
High-Dynamics Piezo Tip/Tilt Platform, 5 mrad, Open-Loop, LEMO Connector

**S-330.8SL**
High-Dynamics Piezo Tip/Tilt Platform, 10 mrad, SGS, LEMO Connector

**S-330.8SD**
High-Dynamics Piezo Tip/Tilt Platform, 10 mrad, SGS, Sub-D Connector

**S-330.80L**
High-Dynamics Piezo Tip/Tilt Platform, 10 mrad, Open-Loop, LEMO Connector

# Anti-Collision System


NONCONTACT POSITION MEASURING SYSTEMS

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Advanced family of high-precision position sensors

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- Ranges from 0.002 to 2.50 inches.
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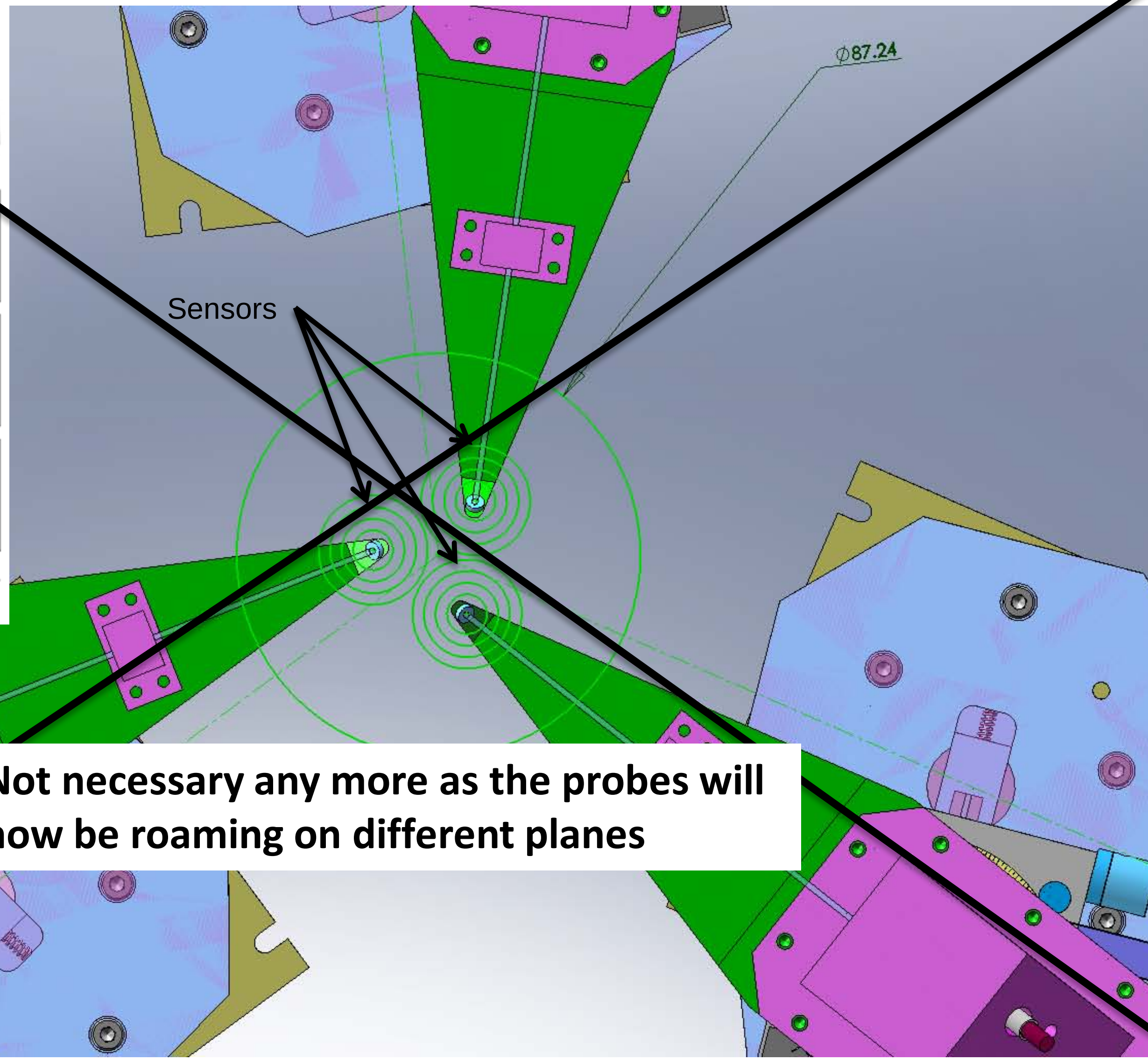


**Not necessary any more as the probes will now be roaming on different planes**

# Remaining work to be done

-Analyze Tip/Tilt Mirror Vibrations and Impact on Probe stabilization.
- System rigidity Analysis

# Questions:

-Probe position Accuracy:  40 (KAON 562) or 70 mas (Contour)
- Minimum Incremental motion ?
- Max Wobble?
- Position Stability (5 mas / 3600 s) TBC
- TT Requirements (Deflection, response, resolution,…)

# Rejected Lever Motors

THORLABS

435 Route 206 • P.O.Box 366
Newton NJ 07860-0366

SALES: (973) 579-7227
FAX: (973) 300-3600
www.thorlabs.com

## Motorized Rotation Stage

- ►Continuous 360° Motorized Rotation With 1arcsec Resolution
- ►Houses Ø1" Optics up to 0.50" Thick
- ►Compatible With Our SM1 Lens Tube Accessories


PRM1Z8


### Overview

### Features

- 1° Graduations on Main Dial
- Compact Design (23 mm Deep)
- Precision Home Limit Switch
- Post Mountable
- Ideal for SM1 (1.035"-40) Compatible Accessories
- Directly Accepts Ø1" Optics up to 0.50" (12.5 mm) Thick
- Fully Compatible with Our SM1 Lens Tube (1.035"-40 Thread) Accessories

| Specification | Value |
|---|---|
| Bidirectional Repeatability | ±0.1° |
| Backlash | ±0.3° |
| Max Rotation Velocity | 25 deg/sec |
| Horizontal On-Axis Load Capacity | 1.5 kg |
| Vertical On-Axis Load Capacity | 0.5 kg |
| Min Achievable Incremental Motion | 25 arcsec |
| Min Repeatable Incremental Motion | 0.03° |
| Absolute On-Axis Accuracy | 0.1% |
| Max Percentage Accuracy | 0.08% |
| Home Location Accuracy | ±0.2° |
| Range | 360° Continuous |

With a depth of only 23 mm (0.9"), the PRM1Z8 is a small, compact, motorized rotation stage and mount that accepts Ø1" optics and is based on our popular PRM1 Rotation Mount. Rotation is driven via a DC servo motor that is equipped with a 67:1 gearbox and a rotary encoder for accurate closed-loop position control. The user can measure the angular displacement by using the Vernier dial in conjunction with the graduation marks that are marked on the rotating plate in 1° increments. The precision DC motor actuator provides 1 arcsecond of resolution over the entire 360° of rotation. This rotation stage/mount is also equipped with a precision home limit switch to facilitate automated rotation to the zero datum position, thus ensuring absolute angular positioning thereafter. The limit switch is designed to allow continuous rotation of the stage over multiple 360° cycles.

The TDC0001 DC | Servo Controller is the ideal companion for achieving smooth, continuous motion that can be automated via the software interface. The stage/mount and controller are sold together below with the item number PRM1Z8E and PRM1/MZ8E.

Normally the PRM1Z8 is mounted horizontally. The stage can be fixed directly to the work surface using the counter-bored holes in the main body. For complete flexibility, the stage/mount can be used vertically on a standard Ø1/2" post and has an option to mount in a vertical inclined orientation. When in the vertical orientation, the reduced thickness of the stage is extremely beneficial for optical path applications where space is limited.

The PRM1Z8 is supplied with 19.6" (0.5 m) of cable. An 8 ft (2.5 m) extension cable (**PAA632**) is available separately.

The rotating platform features several accessories. The central aperture has a standard SM1 internal thread, for

Done

# Rejected Crank Motors

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435 Route 206 • P.O.Box 366
Newton NJ 07860-0366
SALES: (973) 579-7227
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www.thorlabs.com

## 360 Degree Continuous Rotation Stage with Stepper Motor Actuator

- 1 arcsec Microsteps
- 50 kg Load Capacity
- Compatible with LNR and NRT Series Linear Translation Stages


### Overview

### Features

- Resolution Better than 1 arcsec
- Manual Control of the Rotating Carriage
- High Capacity, 50kg Maximum Axial Load
- Preloaded Worm Gear Drive Mechanism with Minimal Backlash
- Origin Indicating Switch Every 360°
- Mounting Options: Four 1/4" (M6) Countersunk Holes and Nine M6 Tapped Holes

The NR series rotation stage provides arc-second resolution when driven from a micro-stepping stepper motor controller, such as the BSC100 Series. The low profile design has a height of just 55 mm due to the use of two compact precision bearings. The rotating carriage of the stage features continuous rotation and can support loads up to 50 kg. The 50 mm clear aperture through the center of the rotation stage allows the stage to be used in applications where the optical axis and rotation axis are parallel. The frame of the stage is made from aluminum and has four 1/4" (M6) countersunk holes that allow the stage to be secured to a translation stage or optical table using one of the adapter plates presented below. In addition, 9 M6 tapped mounting holes are located on the side of the frame to provide additional mounting options. A worm gear assembly transfers the rotary motion of the stepper motor into rotary motion of the carriage. The mechanical reduction in this gear assembly provides one revolution of the carriage for every 66 turns of the stepper motor.

We encourage you to review the tabs above for detailed specifications of the NR360S and the recommended Stepper Motor Controller, the BSC100 Series. Please note that Thorlabs offers bottom mounting adapter plates and brackets to secure the NR360S as well as several types of rotating adapter plates; these items are featured below with more detailed product descriptions.

NR360S
Specs

| Specification | Value |
|---|---|
| **Travel** | 360° Continuous Rotation |
| **On Axis Load Capacity** | 110 lbs (50 kg) |
| **Drive Mechanism** | Worm Drive |
| **Limit Switches** | Reference Signal Every 360° |
| **Motor Type** | 2 Phase Stepper |
| **Theoretical Resolution** | 1 arcsec (If Used with BSC101) |
| **Speed Range** | 15°/ sec (If Used with BSC101) |
| **Recomended Controller** | BSC101 |
| **Weight (Actuator)** | 3.11 lbs (1.4 kg) |

| Motor Specs | |
|---|---|
| **Step Angle** | 1.8° |
| **Rated Phase Current** | 1 A |
| **Phase Resistance** | 4.6Ω |
| **Phase Inductance** | 0.6 mH |
| **Holding Torque** | 23.1 N-cm |
| **Detent Torque** | 1.7 N-cm |
| **Rotor Inertia** | 32 g-cm$^2$ |

Done