

高分辨率压电陶瓷促动器

压电促动器采用以加预载力的堆叠式压电陶瓷,在提供较大推力的同时还可以承受一定的压力,弥补了堆叠式压电陶瓷不能承受压力的不足。上海昊量光电设备有限公司推出的压电促动器拥有极高的分辨率,在 126 μm 的行程中可达到亚纳米分辨率,并且拥有极高的线性度和近乎完美的重复性。

上海昊量光电设备有限公司推出的压电陶瓷促动器主要包含以下两大类:

① 闭环高精度压电陶瓷促动器

闭环压电促动器主要包括 AU-DPT-D、AU-DPT-E、AU-NPS-Z-15B 和 AU-NPS-Z-15L 这几款产品。

AU-DPT-D 是一款内置电容反馈系统的压电促动器,使其拥有亚纳米的分辨率,并且拥有极高的线性度和近乎完美的重复性,极低的蠕变特性和迟滞性。AU-DPT-D 可提供 30/50/70/110 μm 四种不同的闭环行程,材质为不胀钢(0.35nm/K CTE)具有很好的热稳定性。内置预载力的堆叠式压电陶瓷,在整个行程中可提供高达 60kg 的移动质量,并且有较低电子噪声和高的线性度。此外还提供超高真空版本,工作压强范围可从 10^{-3} 到 10^{-10} Torr。



AU-DPT-E 是 AU-DPT-C 的升级产品,可提供 20/50/110 μm 三种不同行程的版本,与 AU-DPT-D 性能相似但其拥有更小的直径。同时 AU-DPT-E 系列也提供超高真空版本,工作压强范围可从 10^{-3} 到 10^{-9} Torr。



AU-NPS-15L 是高荷载大推力的压电陶瓷促动器。该促动器内置电容位移传感器,在全 15 μm 行程中分辨率可达到亚纳米级别,迟滞性<0.02%,直线误差为<0.01%。采用不胀钢材质及特殊的设计,具有极低的热漂移和高的刚度,因此具有极高的稳定性和高的负载,其最大负载可达到 15kg。采用独特的优化机械设计,空载自振频率可到达 8000Hz。

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②开环压电陶瓷促动器

开环压电促动器主要包括 AU-MPT 系列，该压电促动器为有预载力的压电陶瓷，不但可以提供较大的推力还可以承受一定的拉力。AU-MTP 系列促动器可提供 15/30/45/75/105 μm 五种不同行程设备。采用不锈钢材质以及极高刚度的设计，这一特点使其促动器在 Z 轴方向最大加载可达到 10kg。如果需要闭环系统，AU-MTP 系列促动器可以和位置检测系统结合使用，提供亚纳米的分辨率。



③闭环柔性机构促动器

AU-NPS-15B 是内置电容位移传感器的具有柔性机构的压电促动器。柔性铰链导向机构可以去除侧向力，一定程度上避免了侧向力对促动器的损害。采用不胀钢材质，拥有极佳的热稳定性。该促动器拥有极高的分辨率在 15 μm 的行程中分辨率可达到亚纳米级别。内置位移传感器可消除迟滞性、非线性和蠕变性。该产品常规的迟滞性<0.005%,直线性误差<0.01%。空载自振频率可达到 2400Hz，拥有极快的响应速度。



◆主要特点

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- 多种外径尺寸可供选择
- 亚纳米分辨率
- 加载预载力可动态使用
- 可提供超高真空、硬辐射、低温非磁性和高温版本
- 低的迟滞、蠕变性
- 无摩擦
- 柔性机构导向
- 低噪声、高线度
- 亚纳米重复性

◆主要应用

干涉度量学、光束校准、空腔调谐、计量学、显微操作、制作纳米位移设备、度量学等。

◆主要参数

AU-MTP Specification

Parameter	Symbol	Value					Units	Comments
Static physical								
Variant		15	30	45	75	105		
Material		Stainless steel						
Length		30	50	70	110	150	mm	
Diameter		10					mm	
Cable length		2000					mm	
*Range	d_{xp-max}	>15	>30	>45	>75	>105	μm	
Maximum load		10					Kg	Note 1
Stiffness		50	25	16	10	7	$N/\mu m$	
Stack capacitance		1.8	3.6	5.4	9.0	12.6	μF	
Dynamic physical (Typical values)								
Operating Voltage		-20 to +120					VDC	
Operating temperature		+10 to +50					$^{\circ}C$	
Storage temperature 0 to +70 $^{\circ}C$								
Relative humidity		5 to 95 (non-condensing)					%	
Error terms								
*Hysteresis (peak to peak)	$\delta_{xp-hyst}$	≤ 13					%	Note 2
*Linearity error (peak)	δ_{xp-lin}	≤ 6					%	Note 2

Notes

*These parameters are measured and supplied with each mechanism

1. This is the maximum load for gravity acting in the Z-direction to avoid damage to the stage mechanism.
2. Percent error over the full range of motion.

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AU-DPT-D Specification

Parameter	Value								Units	Comments
Variant	AU-DPT-D-20	AU-DPT-D-40	AU-DPT-D-60	AU-DPT-D-100	AU-DPT-D-20-UHV	AU-DPT-D-40-UHV	AU-DPT-D-60-UHV	AU-DPT-D-100-UHV		
Material	Super Invar (0.35nm/K CTE)									Note 1
Length	54.5	72.5	90.5	126.5	54.5	72.5	90.5	126.5	mm	+/- 0.3
Diameter	22	22	22	22	22	22	22	22	mm	
Air Cable Length	2	2	2	2	1	1	1	1		Longer Available On Request
UHV Kapton Cable Length	NA	NA	NA	NA	1	1	1	1		Longer Available On Request
Closed Loop Range	30	50	70	110	30	50	70	110	μm	Minimum
Open Loop Range	40	66	93	146	40	66	93	146	μm	Note 2
Max Force Generation	3500	3500	3500	3500	3500	3500	3500	3500	N	Max Load
Full Range Push Force	600	600	600	600	600	600	600	600	N	Note 3
Max Pull Force	250	250	250	250	250	250	250	250	N	Note 8
Stiffness	80	48	35	22	80	48	35	22	N/μm	Typical
Response (settle) Time	<2	<2	<2	<2	<2	<2	<2	<2	ms	Note 4
Position Resolution	0.09	0.12	0.15	0.2	0.35	0.4	0.5	0.8	nm	Note 5
Operating Temperature	-30 to 80	-30 to 80	-30 to 80	-30 to 80	-30 to 80	-30 to 80	-30 to 80	-30 to 80	°C	Please consult for cryogenic and high temperature
Survival Temperature	-50 to 100	-50 to 100	-50 to 100	-50 to 100	-50 to 100	-50 to 100	-50 to 100	-50 to 100	°C	
Pressure	1Atm	1Atm	1Atm	1Atm	10 ⁻³ to 10 ⁻¹⁰ Torr					
Linearity Error (peak to peak)	<0.03	<0.03	<0.03	<0.03	<0.05	<0.05	<0.05	<0.06	%	Note 6
Repeatability (rms)	0.4	0.4	0.4	0.4	0.8	0.8	0.8	1.2	nm	Typical

Notes

- Housing (out of the thermal expansion loop) in Stainless Steel 316 or 316L on UHV models.
- Typical value for actuators operated in open loop.
- Full closed loop range, forces greater than this may lead temporarily to range reduction.
- 0.5μm step, unloaded with a fast PID setting and using a digital controller
- This is the maximum actual physical rms position noise of the actuator with slow PID settings and the digital controller using standard cable lengths. Longer cable lengths will increase position noise.
- Percent error over the full range of motion using a digital controller.
- Measured at the centre of the actuator displacement.
- Pulling in excess of this value can cause the actuator to require recalibration. Total Preload is 320N, for larger pulling forces add the external preload accessory.

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AU-DPT-E Specification

Parameter	Value						Units	Comments
Static Physical								
Variant	AU-DPT-E-20	AU-DPT-E-50	AU-DPT-E-110	AU-DPT-E-20-UHV	AU-DPT-E-50-UHV	AU-DPT-E-110-UHV		
Supersedes Model	DPT-C-S	DPT-C-M	DPT-C-L	DPT-C-S-UVAC	DPT-C-M-UVAC	DPT-C-L-UVAC		
Material	Super Invar (0.35nm/K CTE)							Note 1
Length	42.2	76.7	127.8	42.2	76.7	127.8	mm	+/- 0.3
Diameter	20	20	20	20	20	20	mm	
Air Cable Length	2	2	2	1	1	1		Longer Available On Request
UHV Kapton Cable Length	0	0	0	1	1	1		Longer Available On Request
Closed Loop Range	20	50	110	20	50	110	μm	Note 2
Open Loop Range	26	66	145	26	66	145	μm	Typical
Blocking Force	3500	3500	3500	3500	3500	3500	N	Typical
Full Range Push Force	600	600	600	600	600	600	N	Note 3
Max Pull Force	200	200	200	200	200	200	N	Note 8
Stiffness	120	48	21	120	48	21	N/ μm	Typical
Response (settle) Time	<2	<2.5	<3	<2	<2.5	<3	ms	Note 4
Dynamic Physical								
Position Resolution	0.2	0.3	0.4	0.4	0.6	0.8	nm	Note 5
Operating Temperature	-30 +80	-30 +80	-30 +80	-30 +80	-30 +80	-30 +80	°C	Please consult for cryogenic and high temperature operation.
Storage Temperature	-50 +100	-50 +100	-50 +100	-50 +100	-50 +100	-50 +100	°C	
Operating Pressure	1Atm	1Atm	1Atm	10 ⁻³ to 10 ⁻⁹ Torr	10 ⁻³ to 10 ⁻⁹ Torr	10 ⁻³ to 10 ⁻⁹ Torr		
Error terms (typical values)								
Linearity Error (peak to peak)	<0.03	<0.03	<0.03	<0.08	<0.08	<0.08		Note 6
Repeatability (rms)	0.5	0.6	0.8	0.8	1	1.2	nm	Typical

Notes

1. Housing (out of the thermal expansion loop) in Stainless Steel 316 or 316L on UHV models.
2. Typical value for actuators operated in open loop.
3. Full closed loop range, forces greater than this may lead temporarily to range reduction.
4. 0.5 μm step, unloaded with a fast PID setting and using a digital controller
5. This is the maximum actual physical rms position noise of the actuator with slow PID setting and the digital controller using standard cable lengths. Longer cable lengths will increase position noise.
6. Percent error over the full range of motion using a digital controller.
7. Measured at the centre of the actuator displacement.
8. Pulling in excess of this value can cause the actuator to require recalibration. Total Preload is 320N, for larger pulling forces add the external preload accessory.



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AU-NPS-15B Specification

Parameter	Symbol	Value			Units	Comments
Static physical						
		Minimum	Typical	Maximum		
Material		Super Invar (Bright nickel plated)				
Size		53 long x 20 diameter			mm	
*Range	d_{zp-max}	± 7.5	± 8.0		μm	
Scale factor	B_{z1}		1		μm	Note 1
*Scale factor error (1σ)	δb_{z1}			0.1	%	
Static stiffness	k_z		20		N·μm ⁻¹	
Resonant frequency:	0g load	$f_{0,0}$	2400		Hz	
	20g load	$f_{0,20}$	1700		Hz	
	100g load	$f_{0,100}$	1200		Hz	
Maximum load				0.5	Kg	Note 2
Dynamic physical (Typical values)						
		Fast	Medium	Slow		Note 3
3dB Bandwidth	B_{zp}	300	250	14	Hz	
*Small signal settle time	t_{zs-s}	1.6	3.2	22	ms	Note 4
*Position noise (1σ)	δz_{p-n}	0.56	0.33	0.25	nm _{rms}	Note 5
Slew rate	u_{zp-max}	2	1	0.2	μm/ms	Note 6
Error terms						
		Minimum	Typical	Maximum		
*Hysteresis (peak to peak)	δz_{p-hyst}		0.005	0.01	%	Note 7
*Linearity error (peak)	δz_{p-lin}		0.01	0.02	%	Note 8
*Rotational error	$\delta \theta_z$			10	μradians	Note 9
*Rotational error	$\delta \gamma_z$			10	μradians	Note 9

Notes

*These parameters are measured and supplied with each mechanism

- All position commands are given in micrometers with seven digit resolution.
- Depends on orientation. 0.5 Kg is the maximum load for gravity acting in the Z-direction. 0.5 Kg is the maximum load for gravity acting in the X or Y axes. Loads greater than 2 Kg can cause damage to the flexure mechanism.
- For dynamic operation the servo-loop parameters are preset for different performances; the parameters are user settable via software control. Fast means the fastest the stage can stably move with less than 20 grams load. Medium means the maximum stable speed for loads up to 100 grams. Slow means the speed at which the servo loop is stable for all masses up to the maximum allowed mass – equivalent to low noise setting.

4. This is the 2% settle time. It is a function of the servo loop parameters which are user controllable. The test step size is 500 nm.

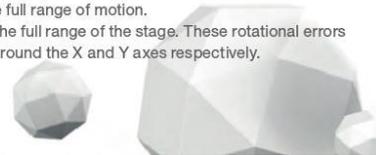
5. The actual position noise of the stage.

6. The highest rate of change of true position with time that can be achieved. It is limited by the closed loop parameters.

7. Percent of the displacement. The hysteresis specification for a displacement of less than 1μm amplitude is 0.1 nm.

8. Percent error over the full range of motion.

9. Angular motion over the full range of the stage. These rotational errors are rotational errors around the X and Y axes respectively.



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AU-NPS-15L Specification

Parameter	Symbol	Value			Units	Comments
Static physical						
		Minimum	Typical	Maximum		
Material		Super Invar (Bright nickel plated)				
Size		53.5 height x 60 diameter			mm	
Cable length			2000		mm	
*Range	$d_{zp,max}$		± 8		μm	
Scale factor	B_{z1}		1		μm	Note 1
*Scale factor error (1 σ)	δb_{z1}		0.05	0.1	%	Note 2
Resonant frequency: 0g load	$f_{0,0}$		8000		Hz	
Maximum load				15	Kg	
Dynamic physical (Typical values)						
		Fast	Medium	Slow		
*Position noise (1 σ)	δz_{p-n}		0.3	0.2	nm _{rms}	Note 3
Slew rate	$U_{zp,max}$		0.1		$\mu m/ms$	Note 4
Error terms						
		Minimum	Typical	Maximum		
*Hysteresis (peak to peak)	δz_{p-hyst}		0.02	0.03	%	Note 5
*Linearity error (peak)	δz_{p-lin}		0.01	0.02	%	Note 6

Notes

*These parameters are measured and supplied with each mechanism

- All position commands are given in micrometers with seven digit resolution.
- This is the difference between the measured scale factor and the desired scale factor of $1\mu m$ motion per $1\mu m$ command. For example a scale factor error of 0.003% means the actuator will move $1.00003\mu m$ when a command of $1\mu m$ is sent to the NPS3330 digital controller.

3. The actual position noise of the stage.

4. The highest rate of change of true position with time that can be achieved. It is limited by the closed loop parameters.

5. Percent of the displacement. The hysteresis specification for a displacement of less than $1\mu m$ amplitude is 0.1 nm.

6. Percent error over the full range of motion.

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