Variable Stiffness Actuators: the user's point of view.

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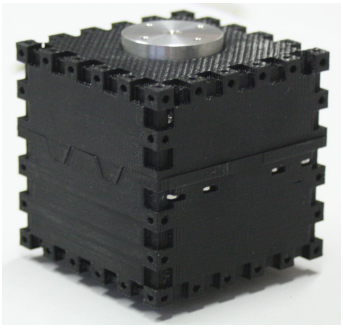
"VSA - CUBE datasheet"

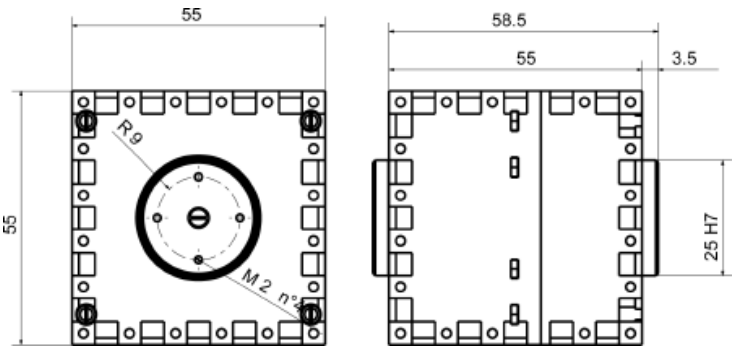
Multimedia Extension #4

International Journal of Robotics Research

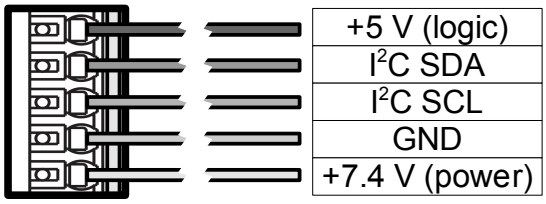
VSA - CUBE

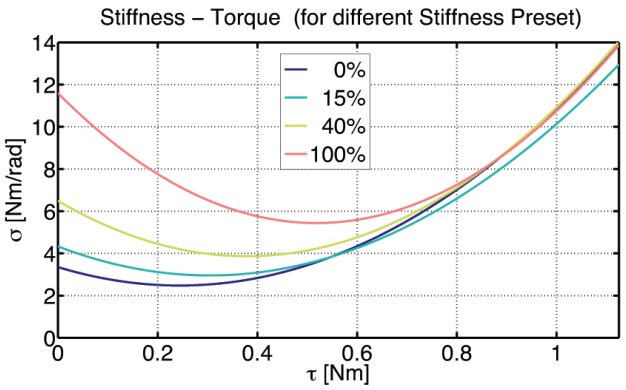
Bidirectional Agonistic - Antagonistic

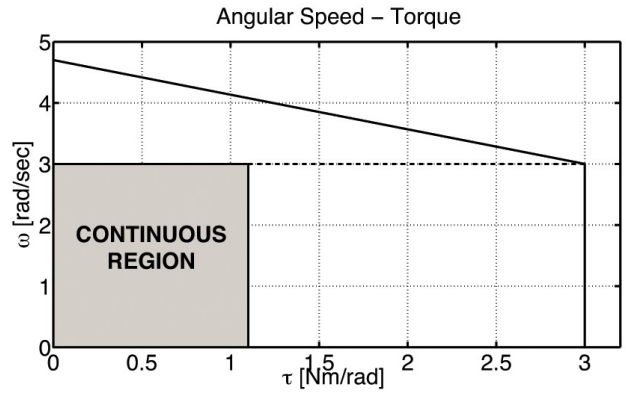


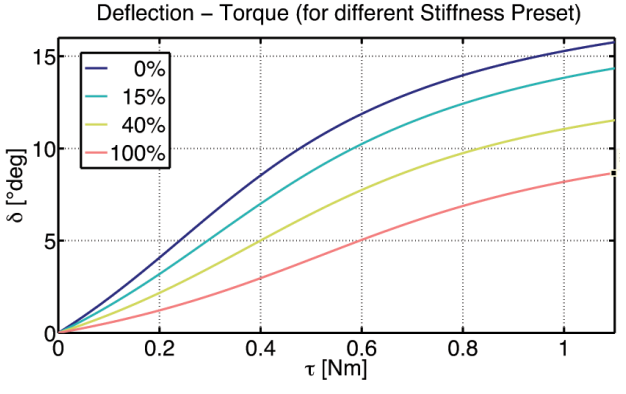


Operating Data				
#	(quantity)		(unit)	(value)
Mechanical				
1	Continuous Output Power		[W]	3.3
2	Nominal Torque		[Nm]	1.1
3	Nominal Speed		[rad/s]	3
4	Nominal Stiffness Variation Time	with no load	[s]	0.18
5		with nominal torque	[s]	0.32
6	Peak (Maximum) Torque		[Nm]	3
7	Maximum Speed		[rad/s]	4.7
8	Maximum Stiffness		[Nm/rad]	14
9	Minimum Stiffness		[Nm/rad]	3
10	Maximum Elastic Energy		[J]	0.047
11	Maximum Hysteresis		[°]	2.5
12	Maximum deflection	with max. stiffness	[°]	8.6
13		with min. stiffness	[°]	15.8
14	Active Rotation Angle		[°]	120
15	Angular Resolution		[°]	0.175
16	Weight		[Kg]	0.260
Electrical				
17	Nominal Voltage		[V]	7.4
18	Nominal Current		[A]	2
19	Maximum Current		[A]	6
Control				
20	Voltage Supply		[V]	5
21	Nominal Current		[A]	0.2
22	I/O protocol		[]	I²C









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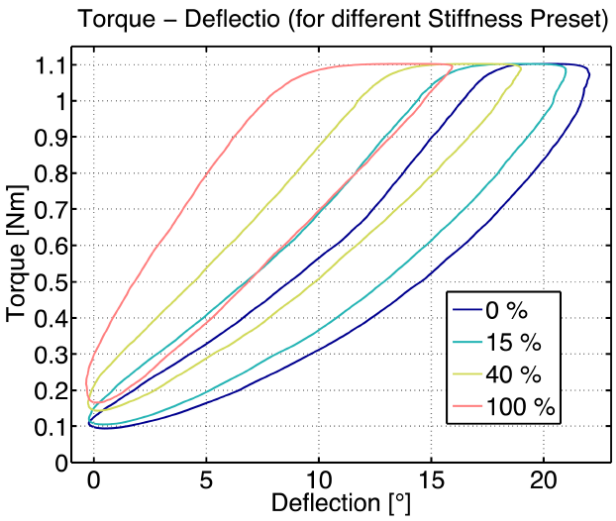
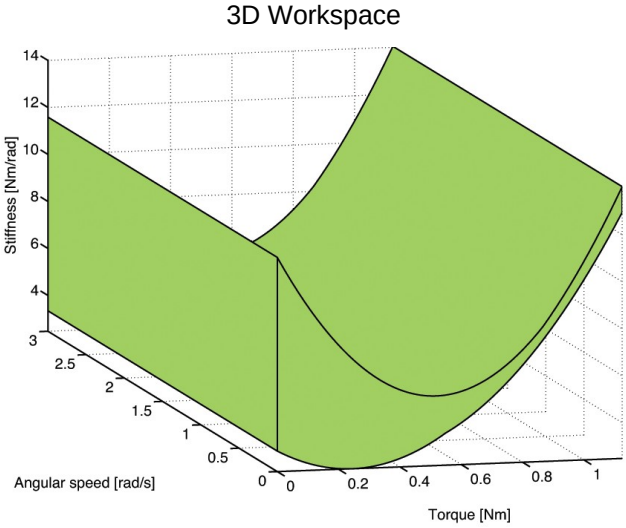
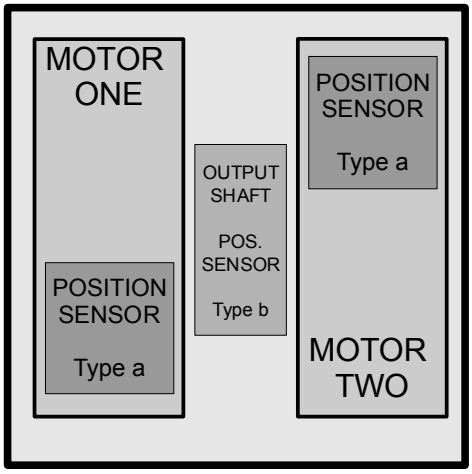
Additional Characteristics



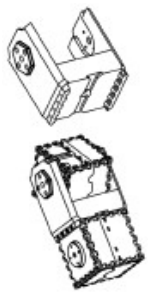
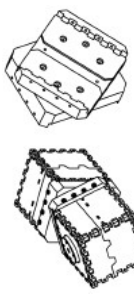
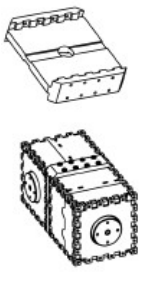


Sensor Map

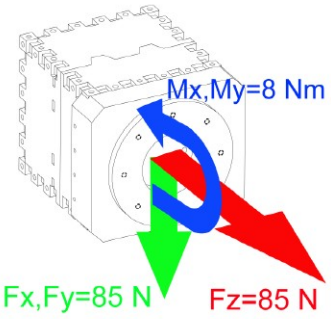
Additional sensors data			
#	(quantity)	(unit)	(value)
a0	**Sensor a**		
a1	Resolution	[°]	0,175
a2	Range	[°]	0 - 270
a3	I/O protocol	[]	Analog
ax	Voltage Supply	[V]	5
b0	**Sensor b**		
b1	Resolution	[°]	0,175
b2	Range	[°]	0 - 360
b3	I/O protocol	[]	Analog
b4	Voltage Supply	[V]	5



Mechanical Connections

Revolute Joint Parallel Axis	Revolute Joint Perpendicular Axis	Rigid Connection
		

Structural Load



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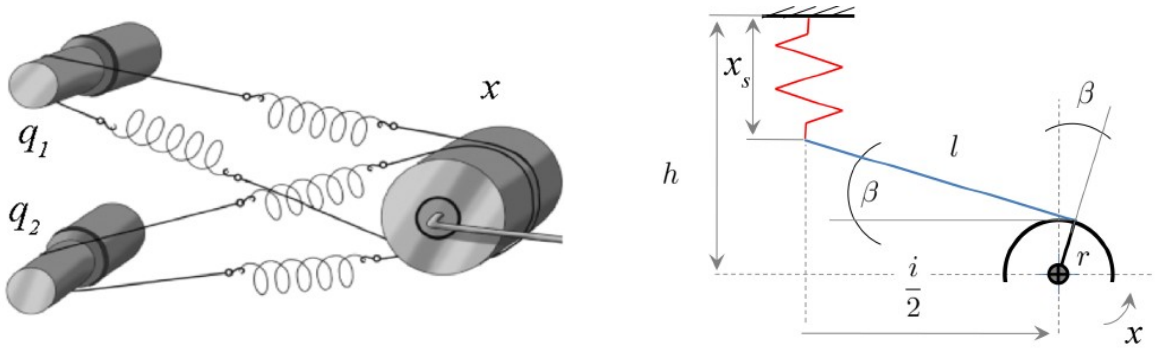
Model



Mathematical model

101	Recoil Point Function	$x_e(q) = \frac{q_1 + q_2}{2}$
102	Energy Function	$H(q,x) = 0.00973 \left(\arcsin\left(2\left\|q_1 - x\right\|\right)^{2.1} + \arcsin\left(2\left\|q_2 - x\right\|\right)^{2.1} \right)$
103	Output Torque Function	$\tau(q,x) = 0.0407 \left(\frac{\arcsin\left(2(q_1 - x)\right)^{1.09}}{\sqrt{1 - 4(q_1 - x)^2}} + \frac{\arcsin\left(2(q_2 - x)\right)^{1.09}}{\sqrt{1 - 4(q_2 - x)^2}} \right)$
104	Output Stiffness Function	$\sigma(q,x) = 0.00973 \left(\left(\frac{9.11 \arcsin\left(2\left\|x - q_1\right\|\right)^{0.0896}}{1 - 4\left(x - q_1\right)^2} + \frac{16.7\left\|x - q_1\right\| \arcsin\left(2\left\|x - q_1\right\|\right)^{1.09}}{\left(1 - 4\left(x - q_1\right)^2\right)^{\frac{3}{2}}} \right) + \left(\frac{9.11 \arcsin\left(2\left\|x - q_2\right\|\right)^{0.0896}}{1 - 4\left(x - q_2\right)^2} + \frac{16.7\left\|x - q_2\right\| \arcsin\left(2\left\|x - q_2\right\|\right)^{1.09}}{\left(1 - 4\left(x - q_2\right)^2\right)^{\frac{3}{2}}} \right) \right)$
105	Spring Torque Function	$e_s(q,x) = \begin{bmatrix} -\frac{0.0407 \arcsin\left(2(q_1 - x)\right)^{1.09}}{\sqrt{1 - 4(q_1 - x)^2}} \\ -\frac{0.0407 \arcsin\left(2(q_2 - x)\right)^{1.09}}{\sqrt{1 - 4q_2 - x)^2}} \end{bmatrix}$
106	Springs to Motors Transmission Ratio	$A(q,x) = \begin{bmatrix} \frac{0.00652 \arcsin(2(q_1 - x))^{0.0448}}{\sqrt{1-4(q_1-x)^2}} & 0 \\ 0 & \frac{0.00652 \arcsin(2(q_2 - x))^{0.0448}}{\sqrt{1-4(q_2-x)^2}} \end{bmatrix}$
107	Springs to Output Transmission Ratio	$B(q,x) = \begin{bmatrix} -\frac{0.00652 \arcsin(2(q_1 - x))^{0.0448}}{\sqrt{1-4(q_1-x)^2}} \\ -\frac{0.00652 \arcsin(2(q_2 - x))^{0.0448}}{\sqrt{1-4(q_2-x)^2}} \end{bmatrix}$