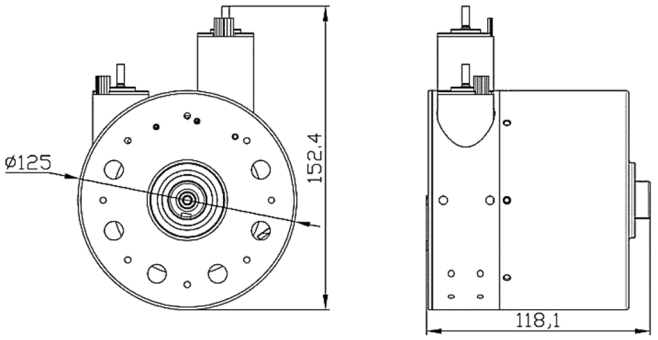
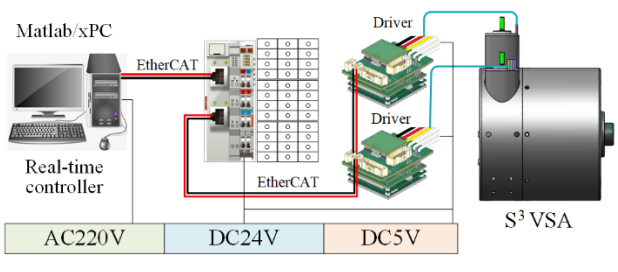
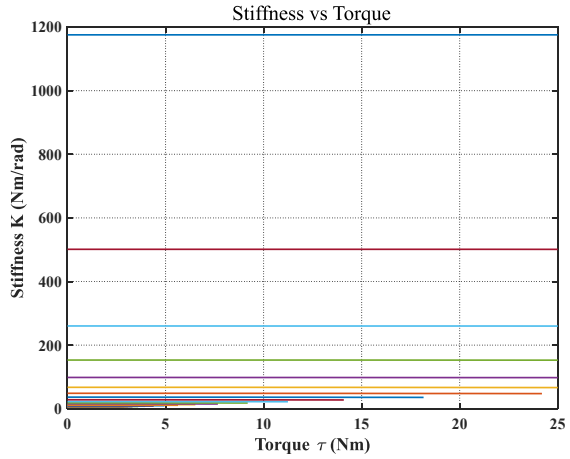
S-shaped Spring Variable Stiffness Actuator (S^{3}VSA)

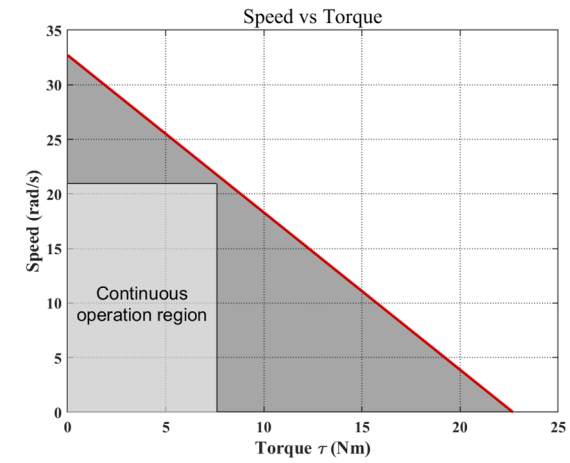
Adjustable Stiffness Joint

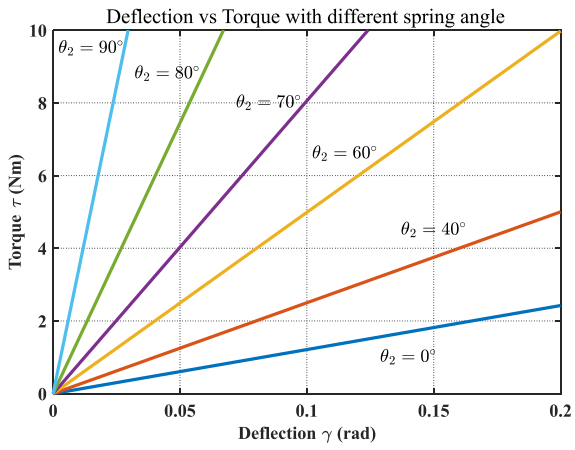


Operating Data				
#	(quantity)		(unit)	(value)
Mechanical				
1	Continuous Output Power		[W]	200
2	Nominal Torque		[Nm]	7.6
3	Nominal Speed		[rad/s]	21.07
4	Nominal Stiffness Variation Time	with no load	[s]	0.08
5		with nominal torque	[s]	0.1
6	Peak (Maximum) Torque		[Nm]	22.7
7	Maximum Speed		[rad/s]	32.72
8	Maximum Stiffness		[Nm/rad]	Inf.
9	Minimum Stiffness		[Nm/rad]	12.12
10	Maximum Elastic Energy		[J]	0.81
11	Maximum Torque Hysteresis		[%]	13.1
12	Maximum deflection	with max. stiffness	[°]	0
13		with min. stiffness	[°]	12
14	Active Rotation Angle		[°]	0-360
15	Angular Resolution		[°]	0.00068
16	Weight		[Kg]	1.54
Electrical				
17	Nominal Voltage		[V]	24
18	Nominal Current		[A]	7.58
19	Maximum Current		[A]	22.74
Control				
20	Voltage Supply		[V]	24
21	Nominal Current		[A]	2
22	I/O protocol		[]	EtherCAT



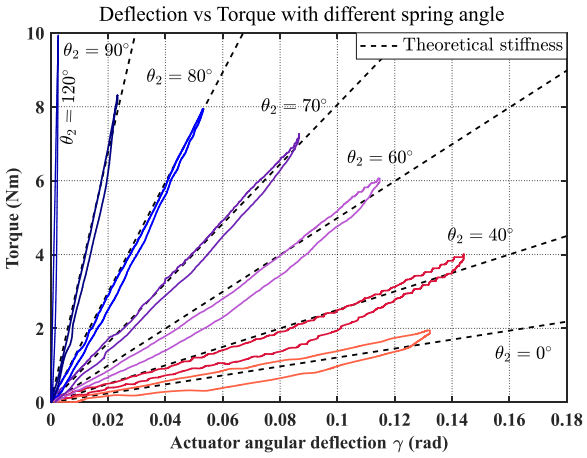


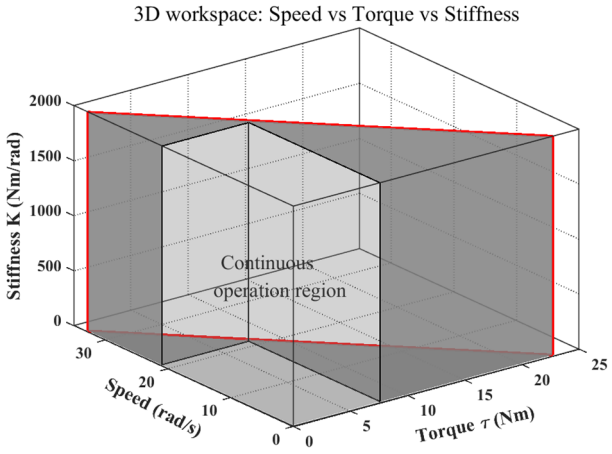




S-shaped Spring Variable Stiffness Actuator (S^{3}VSA)

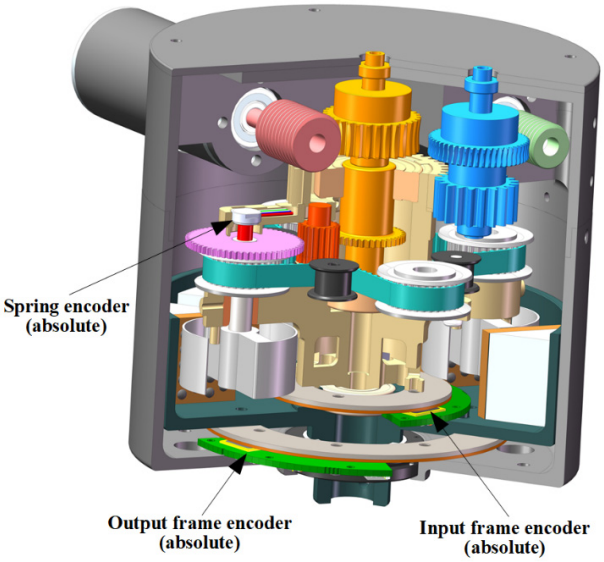
Additional Characteristics

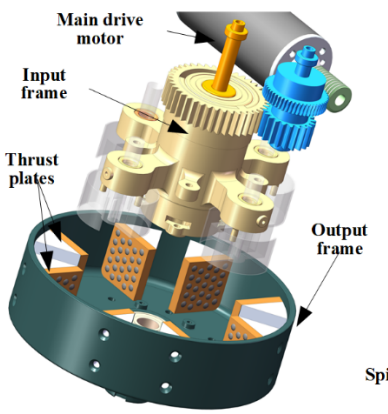


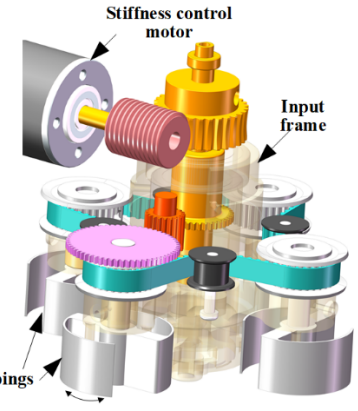


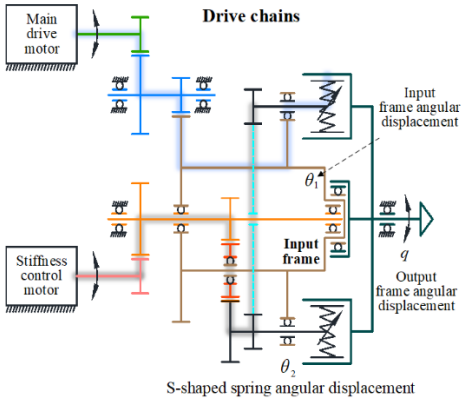
Sensor Map

Additional sensors data			
#	(quantity)	(unit)	(value)
a0	**Input frame encoder**		
a1	Resolution	[bit]	19
a2	Range	[°]	Inf.
a3	I/O protocol		SSI
ax	(specific sensor properties)		absolute
b0	**Output frame encoder**		
b1	Resolution	[bit]	19
b2	Range	[°]	Inf.
b3	I/O protocol		SSI
b4	(specific sensor properties)		absolute
c0	**Spring encoder**		
c1	Resolution	[bit]	12
c2	Range	[°]	Inf.
c3	I/O protocol		SSI
c4	(specific sensor properties)		absolute



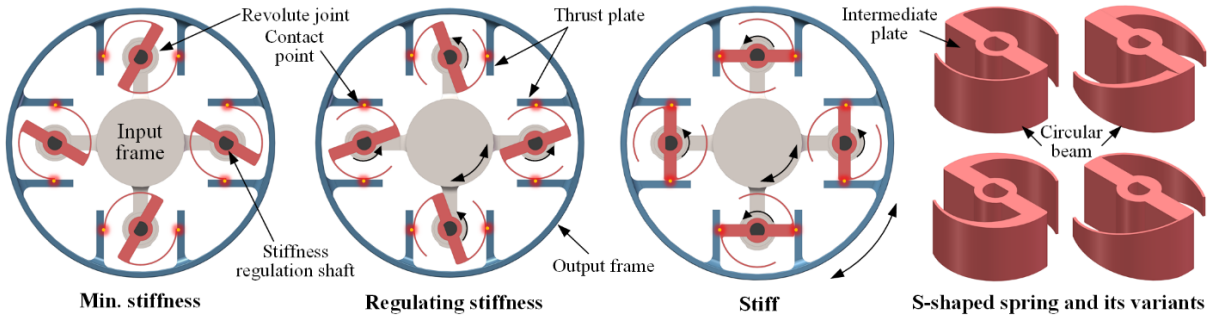




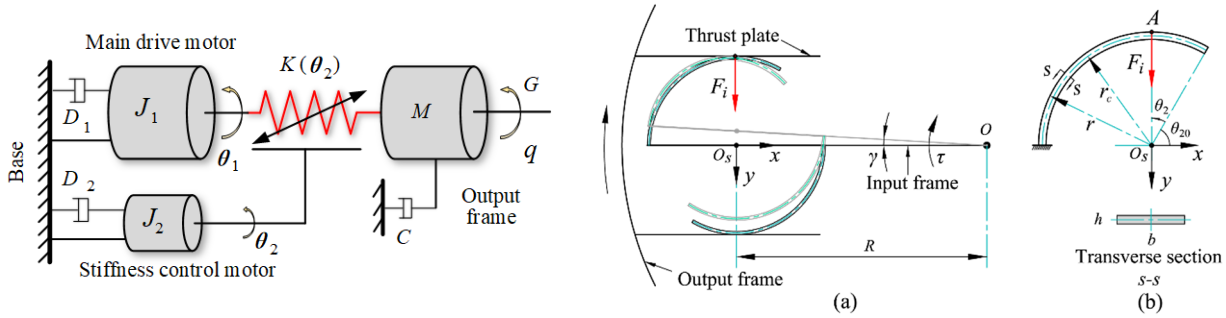


S-shaped Spring Variable Stiffness Actuator (S^3VSA)

Stiffness Regulation Principle



Model



Mathematical model

101	Recoil Point Function	$x_e = \theta_2$
102	Energy Function	$E_s(\theta_1,\theta_2,q) = \dfrac{4NER^2bh^3(1-\cos(\theta_1-q))}{3(2r-h)^3(\pi-(\theta_{20}+\theta_2)+0.5\sin 2(\theta_{20}+\theta_2))}$
103	Output Torque Function	$\tau(\theta_1,\theta_2,q) = \dfrac{4NER^2bh^3\sin(\theta_1-q)}{3(2r-h)^3(\pi-(\theta_{20}+\theta_2)+0.5\sin 2(\theta_{20}+\theta_2))}$
104	Output Stiffness Function	$K(\theta_1,\theta_2,q) = \dfrac{4NER^2bh^3\cos(\theta_1-q)}{3(2r-h)^3(\pi-(\theta_{20}+\theta_2)+0.5\sin 2(\theta_{20}+\theta_2))}$
105	Spring Torque Function	$\tau_r(\theta_1,\theta_2,q) = \dfrac{4NER^2bh^3(1-\cos(\theta_1-q))}{3(2r-h)^3}\left(\dfrac{1-\cos 2(\theta_{20}+\theta_2)}{(\pi-(\theta_{20}+\theta_2)+0.5\sin 2(\theta_{20}+\theta_2)^2}\right)$