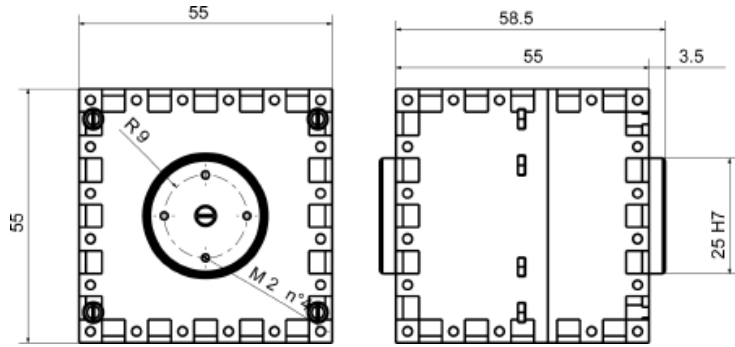
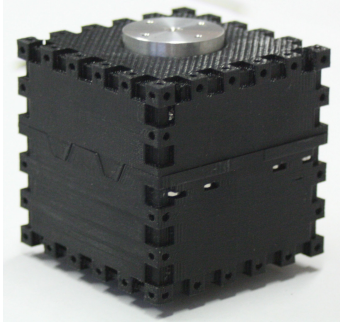


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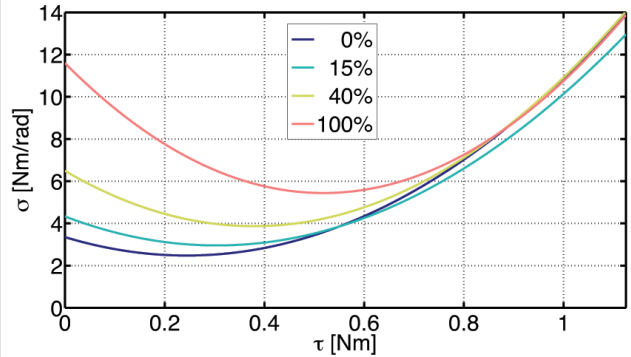
Bidirectional Agonistic - Antagonistic



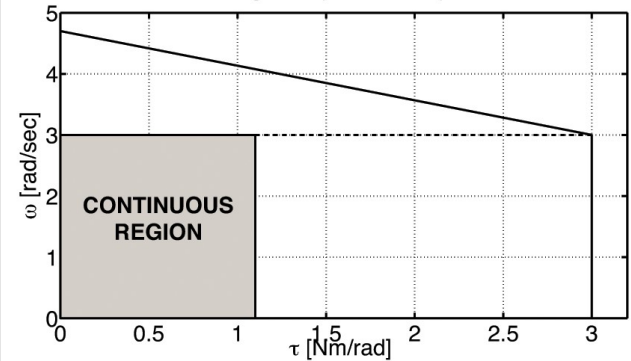
Operating Data

| # | (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 | | I ² C |

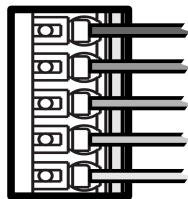
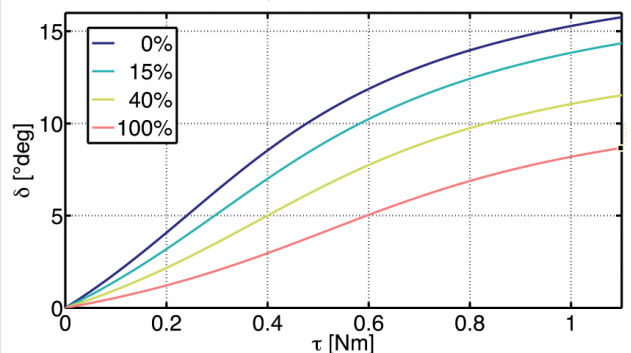
Stiffness – Torque (for different Stiffness Preset)



Angular Speed – Torque



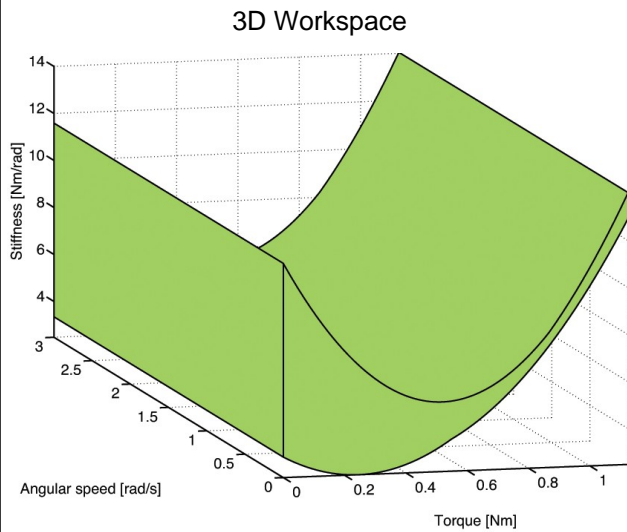
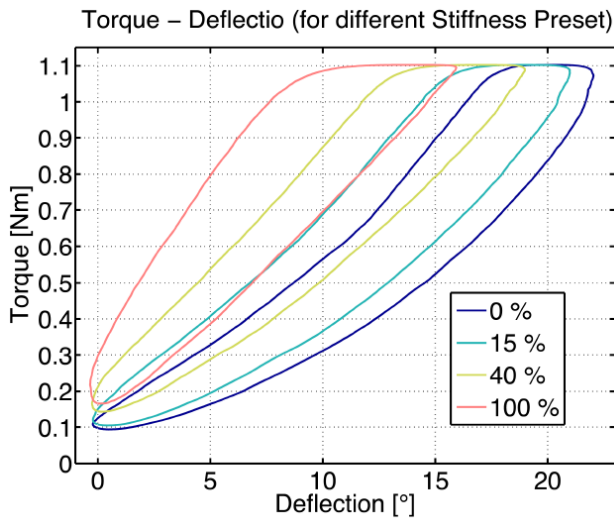
Deflection – Torque (for different Stiffness Preset)



| | |
|--|----------------------|
| | +5 V (logic) |
| | I ² C SDA |
| | I ² C SCL |
| | GND |
| | +7.4 V (power) |

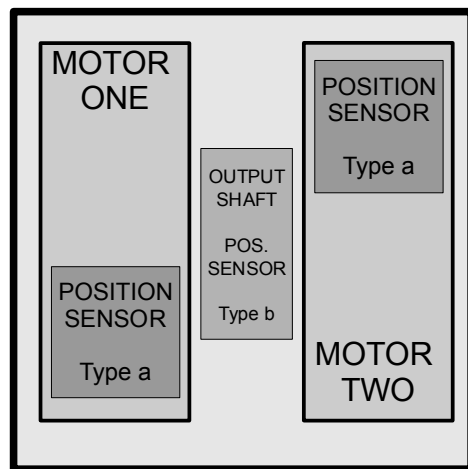
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Additional Characteristics



Sensor Map

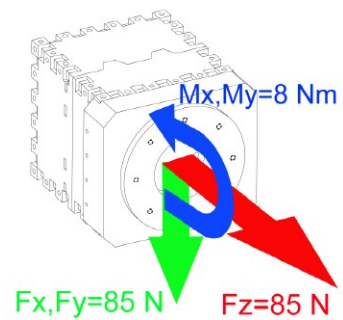
| Additional sensors data | | | |
|-------------------------|----------------|--------|---------|
| # | (quantity) | (unit) | (value) |
| Sensor a | | | |
| a1 | Resolution | [°] | 0,175 |
| a2 | Range | [°] | 0 - 270 |
| a3 | I/O protocol | [] | Analog |
| ax | Voltage Supply | [V] | 5 |
| Sensor b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



Mechanical Connections

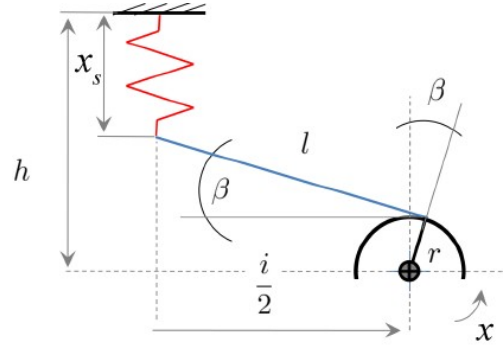
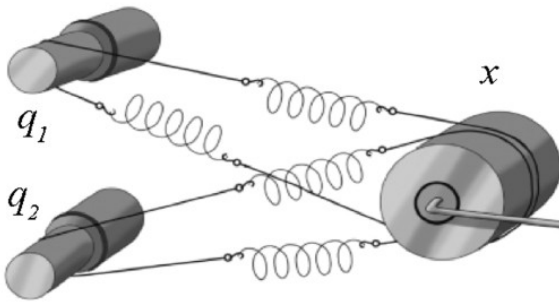
| Revolute Joint Parallel Axis | Revolute Joint Perpendicular Axis | Rigid Connection |
|---------------------------------|--------------------------------------|------------------|
| | | |

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 | $H(q, x) = 0.00973 \left(\arcsin(2 q_1 - x)^{2.1} + \arcsin(2 q_2 - x)^{2.1} \right)$ |
| 103 | Output Torque Function | $\tau(q, x) = 0.0407 \left(\frac{\arcsin(2(q_1 - x))^{1.09}}{\sqrt{1 - 4(q_1 - x)^2}} + \frac{\arcsin(2(q_2 - x))^{1.09}}{\sqrt{1 - 4(q_2 - x)^2}} \right)$ |
| 104 | Output Stiffness Function | $\sigma(q, x) = 0.00973 \left(\left(\frac{9.11 \arcsin(2 x - q_1)^{0.0896}}{1 - 4(x - q_1)^2} + \frac{16.7 x - q_1 \arcsin(2 x - q_1)^{1.09}}{(1 - 4(x - q_1)^2)^{\frac{3}{2}}} \right) + \left(\frac{9.11 \arcsin(2 x - q_2)^{0.0896}}{1 - 4(x - q_2)^2} + \frac{16.7 x - q_2 \arcsin(2 x - q_2)^{1.09}}{(1 - 4(x - q_2)^2)^{\frac{3}{2}}} \right) \right)$ |
| 105 | Spring Torque Function | $e_s(q, x) = \begin{bmatrix} \frac{0.0407 \arcsin(2(q_1 - x))^{1.09}}{\sqrt{1 - 4(q_1 - x)^2}} \\ \frac{0.0407 \arcsin(2(q_2 - x))^{1.09}}{\sqrt{1 - 4(q_2 - x)^2}} \end{bmatrix}$ |
| 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 | $B(q, x) = \begin{bmatrix} \frac{0.00652 \arcsin(2(q_1 - x))^{0.0448}}{\sqrt{1 - 4(q_1 - x)^2}} \\ \frac{0.00652 \arcsin(2(q_2 - x))^{0.0448}}{\sqrt{1 - 4(q_2 - x)^2}} \end{bmatrix}$ |