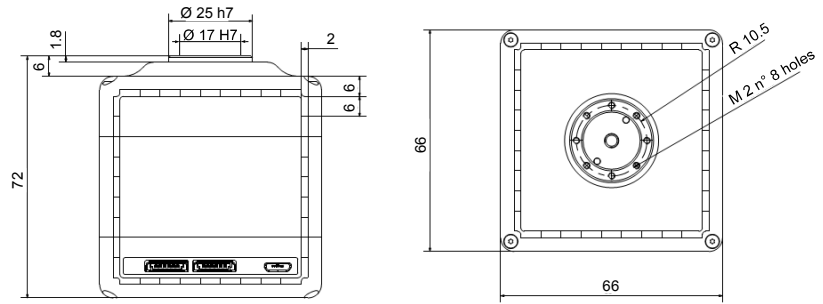
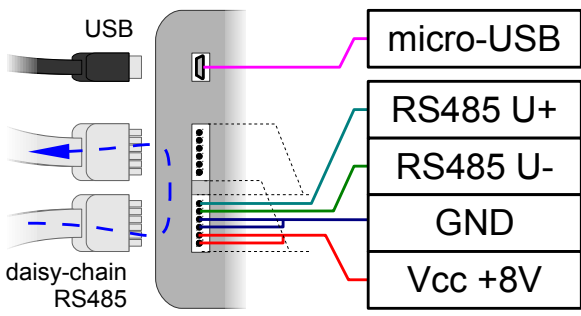
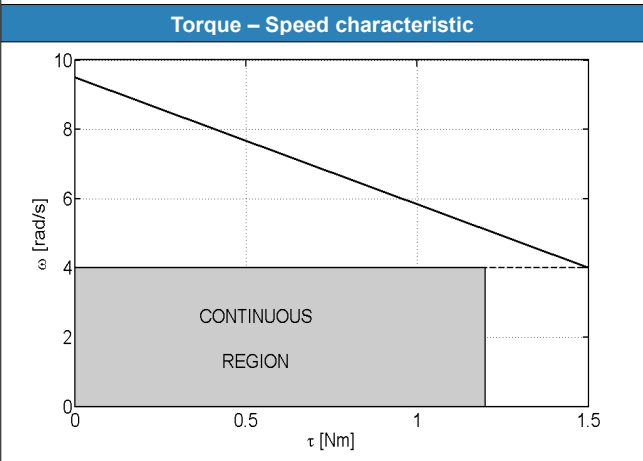
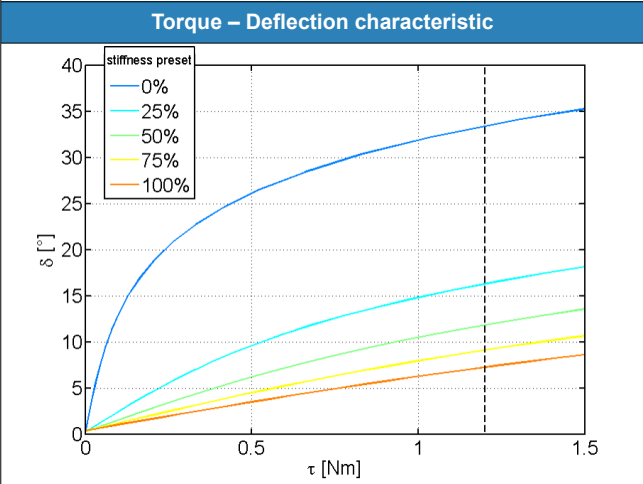
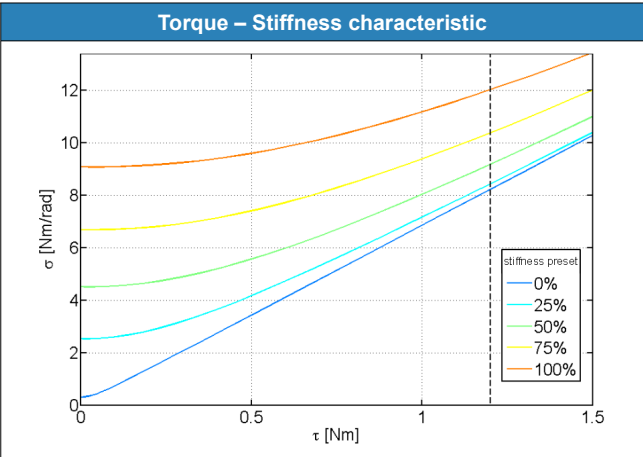


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agonistic/antagonistic servo-VSA



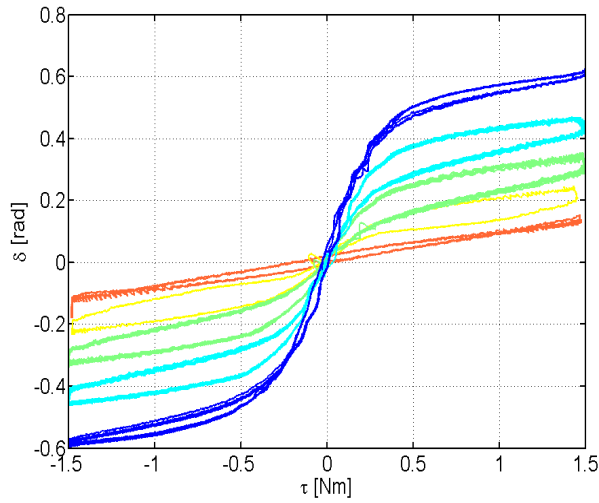
| Operating Data | | | | |
|-------------------|----------------------------------|---------------------|-------------|-----|
| # | (quantity) | (unit) | (value) | |
| Mechanical | | | | |
| 1 | Continuous Output Power | [W] | 4.8 | |
| 2 | Nominal Torque | [Nm] | 1.2 | |
| 3 | Nominal Speed | [rad/s] | 4 | |
| 4 | Peak (Maximum) Torque | [Nm] | 1.5 | |
| 5 | Maximum Speed | [rad/s] | 9.5 | |
| 6 | Maximum Stiffness | [Nm/rad] | 13 | |
| 7 | Minimum Stiffness | [Nm/rad] | 0.5 | |
| 8 | Nominal Stiffness Variation Time | with no load | [s] | 0.2 |
| | | with nominal torque | [s] | 0.2 |
| 10 | Maximum Elastic Energy | [J] | 0.39 | |
| 11 | Maximum Hysteresis | [°] | 6 | |
| 12 | Maximum deflection | with max. stiffness | [°] | 9 |
| 13 | | with min. stiffness | [°] | 36 |
| 14 | Active Rotation Angle | [°] | 180 | |
| 15 | Angular Resolution | [°] | 360 / 32768 | |
| 16 | Weight | [Kg] | 0.260 | |
| Electrical | | | | |
| 17 | Nominal Voltage | [V] | 8 | |
| 18 | Nominal Current | [A] | 2 | |
| 19 | Maximum Current | [A] | 5 | |
| Control | | | | |
| 20 | Voltage Supply (USB) | [V] | 3.3 - 5 | |
| 21 | Nominal Current (USB) | [A] | 0.26 | |
| 22 | I/O protocol | | RS485/USB | |



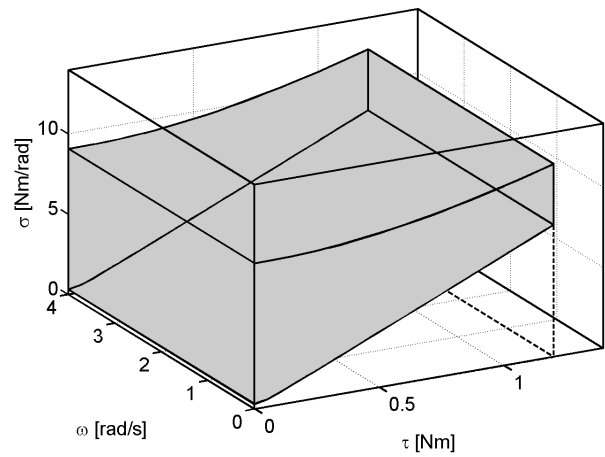
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Experimental Torque – Deflection characteristic



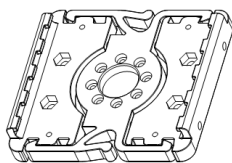
Torque – Speed – Stiffness Workspace



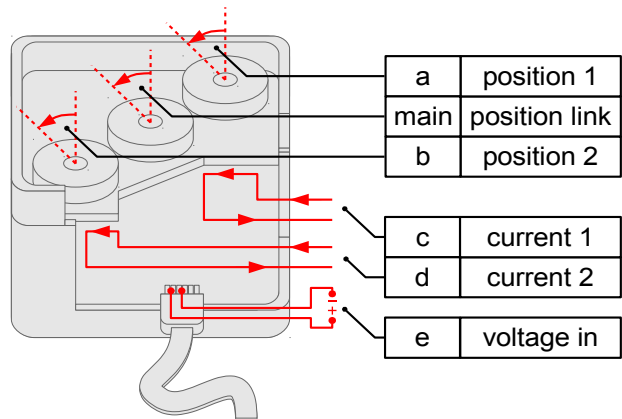
Additional sensors data

| # | (quantity) | (unit) | (value) |
|---------------------------------------|--------------|--------|-------------|
| a0 Sensor a – motor 1 position | | | |
| a1 | Resolution | [°] | 360 / 32768 |
| a2 | Range | [°] | 360 |
| a3 | I/O protocol | □ | int. / SSI |
| b0 Sensor b – motor 2 position | | | |
| b1 | Resolution | [°] | 360 / 32768 |
| b2 | Range | [°] | 360 |
| b3 | I/O protocol | □ | int. / SSI |
| c0 Sensor c – motor 1 current | | | |
| c1 | Resolution | [A] | 5 / 1638 |
| c2 | Range | [A] | 0-5 |
| c3 | I/O protocol | □ | integrated |
| d0 Sensor d – motor 2 current | | | |
| d1 | Resolution | [A] | 5 / 1638 |
| d2 | Range | [A] | 0-5 |
| d3 | I/O protocol | □ | integrated |
| e0 Sensor e – input voltage | | | |
| e1 | Resolution | [V] | 25 / 1638 |
| e2 | Range | [V] | 0-25 |
| e3 | I/O protocol | □ | integrated |

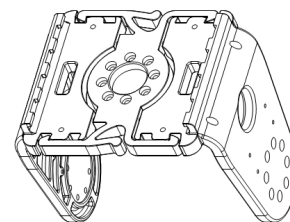
snap-on flat-flange



sensors

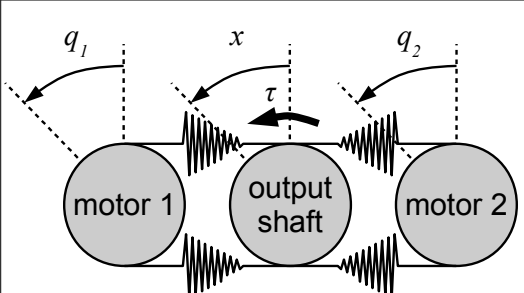
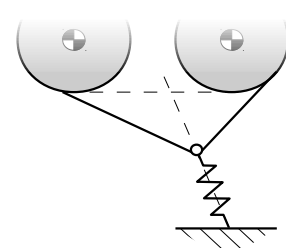


snap-on C-flange (not included)



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sketch

| layout | nonlinear spring | model parameters | |
|---|--|------------------|--------------|
|  |  | value | unit |
| | | k_1 | 0.0227 Nm |
| | | a_1 | 6.7328 1/rad |
| | | k_2 | 0.0216 Nm |
| | | a_2 | 6.9602 1/rad |

mathematical model (approx.)

| | | |
|-----|-------------------|---|
| 101 | equilibrium point | $x_e = (q_1 + q_2)/2$ |
| 102 | output stiffness | $\sigma = a_1 k_1 \cosh(a_1(x - q_1)) + a_2 k_2 \cosh(a_2(x - q_2))$ |
| 103 | output torque | $\tau = k_1 \sinh(a_1(x - q_1)) + k_2 \sinh(a_2(x - q_2))$ |
| 104 | elastic energy | $H = \frac{k_1(\cosh(a_1(x - q_1)) - 1)}{a_1} + \frac{k_2(\cosh(a_2(x - q_2)) - 1)}{a_2}$ |

online community

www.naturalmotioninitiative.org

open distribution model

| project component | open license |
|---------------------------|--------------------------------------|
| mechanical drawings | CC BY (Creative Commons Attribution) |
| electronic schematics | CC BY (Creative Commons Attribution) |
| micro-controller firmware | 3-clause BSD license |
| software libraries | 3-clause BSD license |