

## ROZUM ROBOTICS SERVO MOTORS: ENDURANCE TEST PROTOCOL

**Rozum Robotics cobot official warranty:** 1 year

*In accordance with EU regulations set for robot manufacturers*

**Declared cobot lifetime:** 35 000 hours (4 years 24/7 work)

Lifetime for servomotors as a key cobot component is calculated through accelerated endurance testing with dynamic load: <http://bit.ly/testload>

### INITIAL PARAMETERS

Lever length	400 mm
Total payload	5,7 kilo
Working angle	180°
Working temperature, max	85 °C
Acceleration, max (load amount)	800 °/c <sup>2</sup>
Non-stop working cycle	acceleration–permanent speed–braking

### CONTROLLED PARAMETERS (Annex 1)

Current, max (phase and/or RMS)  
Motor temperature (not more than 85 °C)  
Noise level (not more than 55 dB)  
Power (peak/average)  
Cycle time  
Overall visual control

### CALCULATIONS IN ACCORDANCE WITH HARMONIC DRIVE INSTRUCTIONS FOR STRAIN-WAVE GEARHEAD CPL-14A (Annex 2)

**Average torque output** (formula 18.2):

$$T_n = 20 N \cdot m$$

**Average input velocity** (formula 18.4):

$$n = 2175 \text{ rpm}$$

**Working lifespan** (formula 18.11):

$$L = 35\,000 \cdot \frac{2175}{3\,500} \cdot \left(\frac{7.8}{20}\right)^2 = 3\,300 \text{ hours}$$

**Testing start date:** 14.12 2017

On condition, testing is finished successfully on May 04, 2018, the endurance of Rozum Robotics servomotors will be proved and confirmed experimentally. 3 300 test hours will be equal to 35 000 hours of real environment testing.

Rozum Robotics LLC  
CEO  
Viktar Khamianok



## Computer software data: dynamic load tests of Rozum Robotics servomotors

Profile 1

Cycle Time  Temperature  Ip Peak  Iph Avg  Irms Peak  Irms Avg  P Peak  P Avg  Err Vel Peak  Err Vel Avg  Err Pos Peak  Err Pos Avg  Show table

Params:

Time: 2560.254  
 Cycle Time: 0.000  
 Temperature: 84.622  
 Ip Peak: 9.679  
 Iph Avg: 4.268  
 Irms Peak: 9.679  
 Irms Avg: 4.268  
 P Peak: 409.748  
 P Avg: 180.686  
 Err Vel Peak: 249.853  
 Err Vel Avg: 96.540  
 Err Pos Peak: 2.409  
 Err Pos Avg: 1.226  
 Vin: 42.332  
 Cmode: 6.000  
 Tsv: 17.312  
 Nav: 8.484

Cycles: 662  
 Error Count: 1

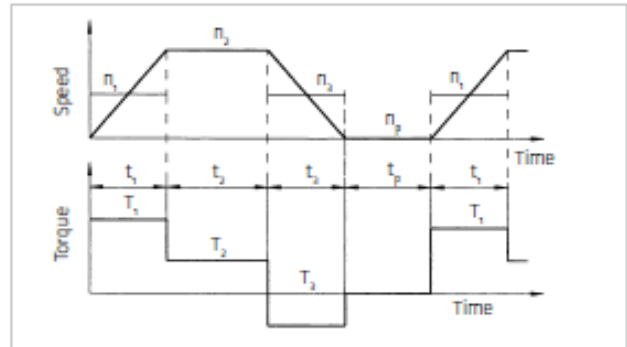
Temperature: 84.6°  
 Total time: 2 days 03:24:05

	Cycle Time	Temperature	Ip Peak	Iph Avg	Irms Peak	Irms Avg	P Peak	P Avg	Err Vel Peak	Err Vel Avg	Err Pos Peak	Err Pos Avg
185010.9219	2.5310	82.4017	9.6448	4.2553	9.6448	4.2553	402.6067	177.6295	250.9430	95.3267	2.4099	1.2238
185013.3594	2.5320	82.7112	9.6918	4.2608	9.6918	4.2608	408.6622	179.6593	250.2197	95.5258	2.4096	1.2243
185015.7812	2.5320	82.8669	9.6636	4.2618	9.6636	4.2618	410.2466	180.9235	250.5325	95.6565	2.4111	1.2273
185018.4219	2.5310	83.0233	9.6834	4.2592	9.6834	4.2592	406.7034	178.8855	250.0605	94.9043	2.4091	1.2239
185020.8594	2.5320	83.3377	9.6729	4.2619	9.6729	4.2619	411.2245	181.1877	249.5746	96.0136	2.4107	1.2293
185023.5000	2.5310	83.4959	9.6691	4.2583	9.6691	4.2583	404.3509	178.0787	250.0800	96.4046	2.4107	1.2257
185025.9531	2.5320	83.6548	9.6281	4.2562	9.6281	4.2562	405.5426	179.2717	250.5139	94.6005	2.4114	1.2209
185028.5781	2.5320	83.8142	9.6479	4.2623	9.6479	4.2623	405.7917	179.2739	250.6189	94.5574	2.4112	1.2222
185031.0156	2.5310	83.9744	9.6440	4.2521	9.6440	4.2521	405.4844	178.7784	250.2617	95.3649	2.4095	1.2249
185033.6719	2.5320	84.1352	9.6589	4.2607	9.6589	4.2607	404.6528	178.4977	250.2231	95.8571	2.4103	1.2280
185036.1094	2.5320	84.2159	9.6422	4.2690	9.6422	4.2690	407.1524	180.2617	250.4360	97.8066	2.4090	1.2344
185038.7344	2.5310	84.4588	9.6864	4.2662	9.6864	4.2662	404.1977	178.0207	250.0303	96.0438	2.4125	1.2282
185041.1719	2.5320	84.4588	9.6682	4.2653	9.6682	4.2653	409.5667	180.6868	250.4201	95.8504	2.4088	1.2262
<b>185043.8125</b>	<b>2.5310</b>	<b>84.6216</b>	<b>9.6794</b>	<b>4.2683</b>	<b>9.6794</b>	<b>4.2683</b>	<b>403.7584</b>	<b>178.0451</b>	<b>249.8526</b>	<b>96.5399</b>	<b>2.4092</b>	<b>1.2265</b>

### Endurance test instruction for Harmonic Drive CPL-14A strain-wave gearhead

Torques	$T_1 \dots T_n$	[Nm]
during the load phases	$t_1 \dots t_n$	[s]
during the pause time	$t_p$	[s]
and output speeds	$n_1 \dots n_n$	[rpm]
Emergency stop/ momentary peak torque at output speed	$T_k$	[Nm]
	$n_k$	[rpm]
and duration	$t_k$	[s]

Illustration 18.1



Equation 18.2

**Load limit 1,**  
Calculation of the Average Output Torque  $T_{av}$

$$T_{av} = \sqrt[3]{\frac{|n_1 \cdot T_1^3| \cdot t_1 + |n_2 \cdot T_2^3| \cdot t_2 + \dots + |n_n \cdot T_n^3| \cdot t_n}{|n_1| \cdot t_1 + |n_2| \cdot t_2 + \dots + |n_n| \cdot t_n}}$$

Equation 18.3

Values for TA see Technical Data  
 $T_{av} \leq T_A$

No → Selection of a bigger size

Equation 18.4

Calculation of the average output speed

$$n_{out,av} = \frac{|n_1| \cdot t_1 + |n_2| \cdot t_2 + \dots + |n_n| \cdot t_n}{t_1 + t_2 + \dots + t_n + t_p}$$

Equation 18.5

Average input speed  
 $n_{in,av} = i \cdot n_{out,av}$

Equation 18.6

Permissible maximum input speed  
 $n_{in,max} = n_{out,max} \cdot i \leq$  Maximum input speed (see Technical Data)

Equation 18.7

Permissible average input speed  
 $n_{in,av} \leq$  Limit for average input speed (see Technical Data)

Equation 18.8

**Load limit 2,  $T_E$**   
 $T_{max} \leq T_E$

Equation 18.9

**Load limit 3,  $T_M$**   
 $T_k \leq T_M$

Equation 18.10

Allowable number of momentary peak torques

$$N_{k,max} = \frac{10^4}{2 \cdot \frac{n_k}{60} \cdot t_k} < 10^4$$

Equation 18.11

Operating life

$$L_{50} = L_n^* \cdot \frac{\text{Rated input speed}}{n_{in,av}} \cdot \left( \frac{\text{Rated torque } T_n}{T_{av}} \right)^2$$