

Beam Wire Scanner for PS/SPS/PSB

Motor Selection

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Electric Motor Requirements

* - The motor currently used is obsolete and will not be available for purchasing

Parameter	Value		Notes
Motor type	Frameless PMSM		Permanent Magnet Synchronous Motor
Rotor core material	Steel (should be approved by CERN)		
Permanent magnets material	Samarium-Cobalt ($\text{Sm}_2\text{Co}_{17}$)		
Wire linear speed, m/s	20		
Angular speed, rad/s	110 (PS/SPS)	133 (PSB)	
Acceleration, rad/s ²	10672 (PS/SPS)	15711 (PSB)	Sin-profile is used, spec. coefficient 1.85
Inertia of the load, kg x m ²	8.6E-04* (PS/SPS)	7.29E-04* (PSB)	
Radial air gap (stator ID – rotor ED), mm	0.7		
Ionizing radiation dose, kGy/year	1		

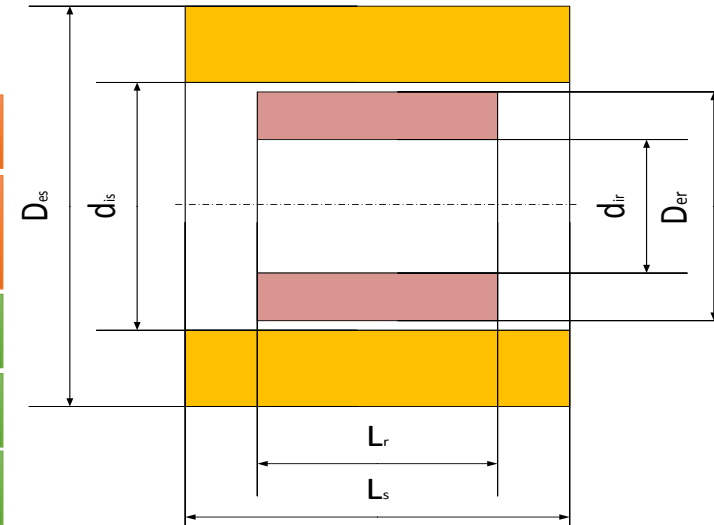
New motor will be the same in beam wire scanners for PS/SPS/PSB so should provide torque sufficient to accelerate the wire to linear speed 20 m/s in both configurations: 182.5 mm (PS/SPS) and 150 mm (PSB) mm forks;

- The desired motor should be based on the standard market solution which will be available for many years;
- The rotor will be located in vacuum and must be vacuum compatible; the use of any glue, other adhesives or insulating materials is not possible. Solid core rotor should be used.
- The moment of inertia of the rotor should be minimized in order to reduce the required acceleration torque;
- Features for mounting the rotor on the shaft (key-slots, holes, etc.) should be considered in the design;

*-values will be optimized during the next mechanical design phase

Potential suppliers and models

Supplier	Model	Rotor Inertia, kg x m ²	Peak torque, N x m	Required torque PS/SPS, N x m	Required torque PSB, N x m	Dimensions, d _{ir} xD _{er} xD _{es} xL _r xL _s
Alxion	145STK2M	1.28E-03	55.00	20.07	27.48	56x??x145x86x119
Kollmorgen	KBM-35X02	2.50E-03	58.4	35.86	50.73	65x??x140x76x109
Parker	NK620	9.80E-04	26.60	18.63	25.57	26x71x111x60x106



3 companies are interested

Potential suppliers and models. Prices

Supplier – Model	Price for prototype, EUR	Price for series, EUR	Additional cost	Delivery time, weeks	Total, prototype x1	Total, prototype x2
Parker - NKD620EKxR1000	3154		-	10	3154	6308
Kollmorgen - KBM-35X02	5294	3566	3700 (NRE)	16	8994	14288
Alxion - 145STK2M	5250	1860	2700	14	7950	13200
Alxion - 145STK4M	5710	2280	2900	14	8610	14320

baseline



Parker - NK620



Rotor banding
(done by Alxion)

Supplier – Model	Price for 1, EUR	Price for 2, EUR
Parker - NKD620EKxR1000	---	---
Kollmorgen - KBM-35X02	1078	2157
Alxion - 145STK2M	2710	4060
Alxion - 145STK4M	3150	4880

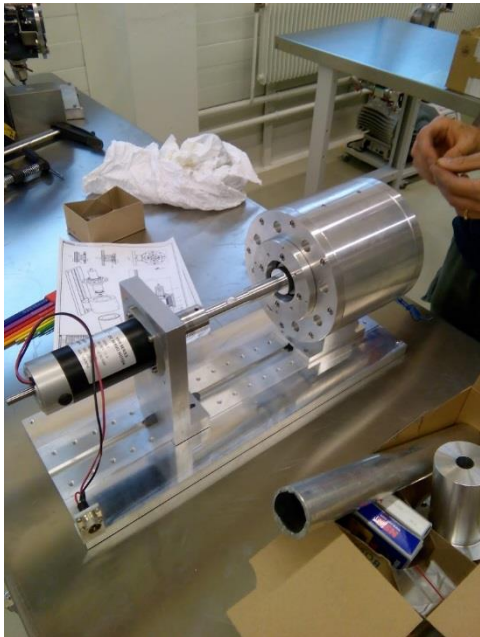
Delivery time for standard models: Alxion – by 30.10; Kollmorgen – app. 7 weeks.

Test bench status

- It was decided to order 3 motors for qualification. All of them have been delivered.
- 2 Test benches were designed, produced and assembled for qualification tests.
- Test benches are ready for electromechanical tests.

Company	Model	P.O. sent	Delivery expected
Alxion	145STK2M1C020S (standard)		DELIVERED
Kollmorgen	KBM-35H02-C00 (standard)		DELIVERED
Alxion	145STK2M - customised		DELIVERED

Kollmorgen motor test bench:



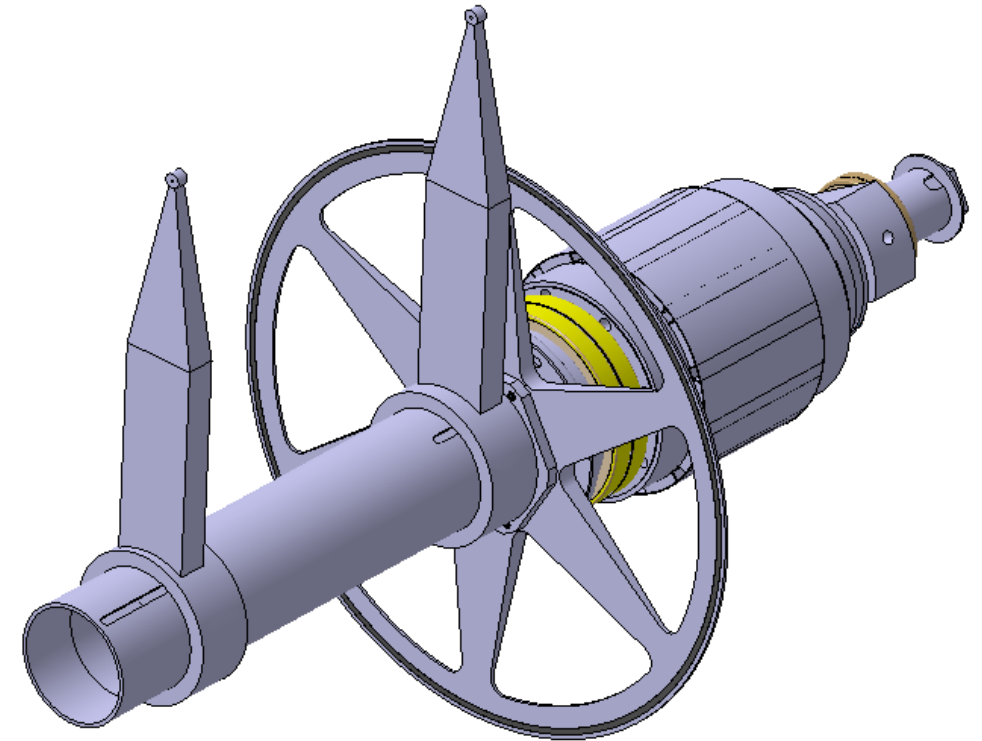
Alxion motor



Definition (update) of inertia at final design phase (Dec-15)

Moment of inertia for the shaft and components installed on it

Component	J	% of load
Bearing 1	1.96E-05	0.80%
Bearing 2	2.45E-06	0.10%
Optical disk	2.36E-04	9.62%
Nuts on the shaft	1.20E-04	4.89%
Fork with fixation ring and screws	8.25E-05	3.36%
Fork with fixation ring and screws	8.25E-05	3.36%
Resolver	1.12E-05	0.46%
Magnetic lock	6.61E-05	2.69%
Rotor (Alxion)	1.28E-03	52.15%
Shaft	5.54E-04	22.57%
TOTAL	2.45E-03	100%

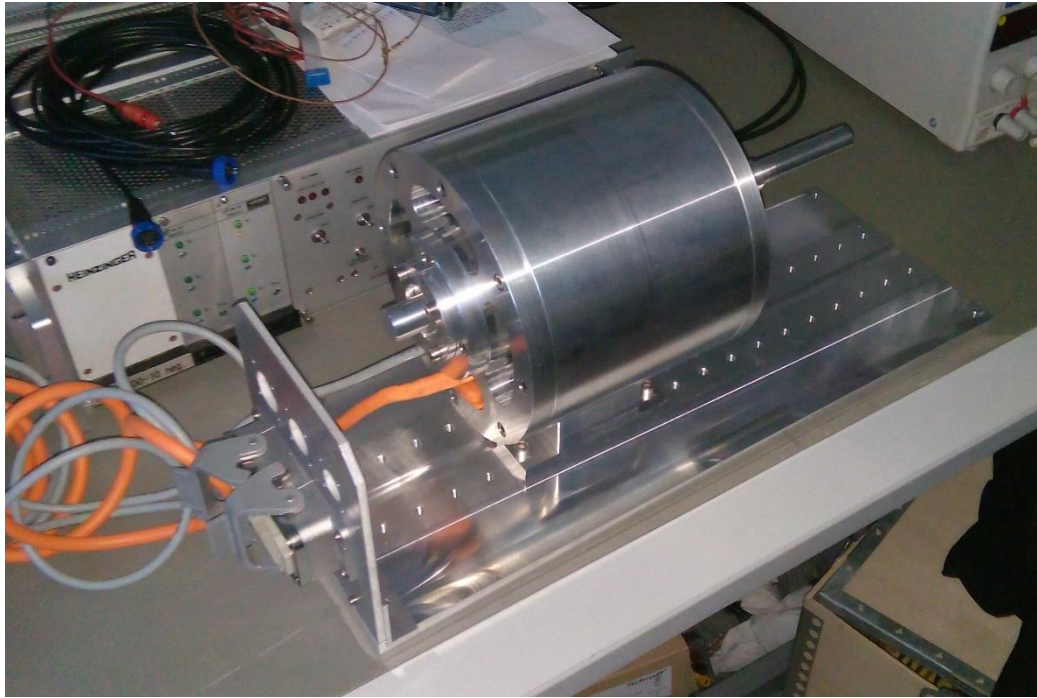
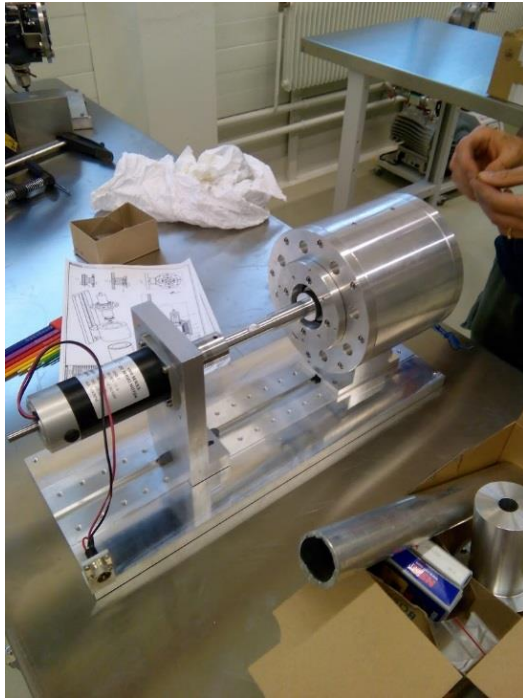


Motor	Tc, Nm	Jr, kg.m ²	Jtotal R2	Peak torque	Required torque, Nm	% of peak torque	% left
Alxion 145STK2M	14.6	1.28E-03	2.45E-03	55	38.56	70%	30%
Kollmorgen KBM-35X02	17.5	2.50E-03	3.67E-03	59.2	57.73	98%	2%

*Optical disk can be optimised to reduce the total inertia by several %
+ other components can be optimised (lock nuts material; forks)*

Conclusions

- Inertia of the load has changed during the design phase ($8.6E-4$ before; $1.11E-3$ now).
- Updated BWS structure inertia load requires around 70% of the baseline motor (**Alxion - 145STK2M**) peak torque.
- Qualification is planned and the test bench is ready for electromechanical tests.
- Further purchase of motors is planned after electromechanical tests are completed.



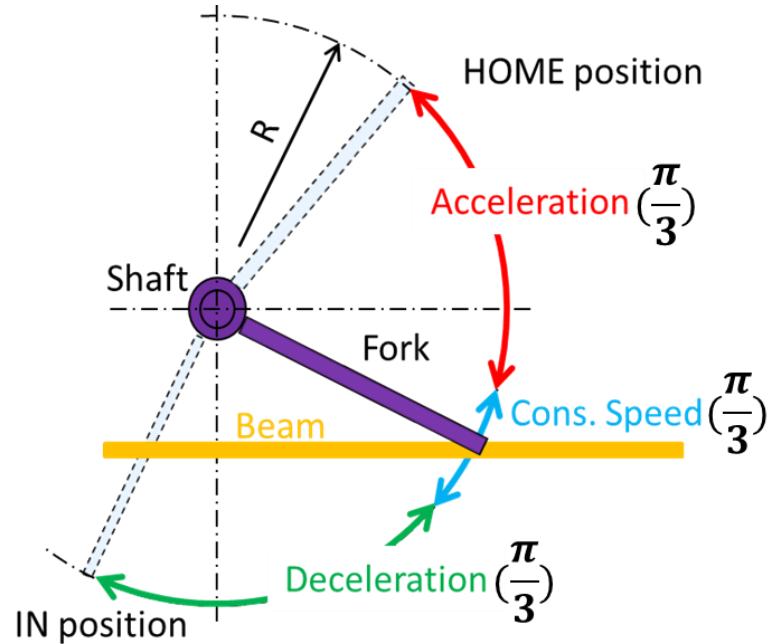
Thank you for your attention!

Questions?

...Discussion...

Extra slides

Torque required for acceleration of the wire scanner forks in order to achieve the velocity of 20 m/sec on the distance of 60° ($\frac{\pi}{3}$)



3 different lengths of the fork have been considered:

Option 1: **R1 = 182.5 mm**

Option 2: **R2 = 150.0 mm**

Option 3: **R3 = 100.0 mm**

Equations used for calculation:

$$\omega_f = \omega_i + \alpha t \quad (1)$$

$$\theta = \omega_i t + \frac{1}{2} \alpha t^2 \quad (2)$$

$$\omega_f^2 = \omega_i^2 + 2\alpha\theta \quad (3)$$

$$\theta = \frac{1}{2} (\omega_f + \omega_i) t \quad (4)$$

Angular speed and acceleration

	Length of the fork, m	Linear speed of the wire, m/s	Angular speed of the wire, rad/s	Acceleration (constant), rad/s ²	Peak acceleration (variable profile, k=1.85*), rad/s ²
Option 1 (R1)	0.182	20	110	5790	10711.5
Option 2 (R2)	0.150	20	133	8471	15671.4
Option 3 (R3)	0.100	20	200	19108	35350.0

* - the coefficient used for calculations of the peak acceleration by C. Grosjean

**Moment of inertia of the shaft and components installed on it
(based on data from S. Samuelsson)**

Component	J (kg × m ²) for R1 (182.5 mm)	J (kg × m ²) for R2 (150 mm)	J (kg × m ²) for R3 (100 mm)
Bearing 1	1.96E-05	1.96E-05	1.96E-05
Bearing 2	2.45E-06	2.45E-06	2.45E-06
Disc	1.45E-04	1.45E-04	1.45E-04
Disc holder	2.01E-05	2.01E-05	2.01E-05
Fork with fixation ring and screws	1.56E-04	9.03E-05	3.81E-05
Fork with fixation ring and screws	1.56E-04	9.03E-05	3.81E-05
Resolver	4.00E-06	4.00E-06	4.00E-06
Magnetic lock	6.61E-05	6.61E-05	6.61E-05
Rotor	3.46E-04	3.46E-04	3.46E-04
Shaft	2.91E-04	2.91E-04	2.91E-04
Total (J_{total})	1.21E-03	1.07E-03	9.70E-04

Summary table of calculated data for torque and acceleration

	Length of the fork, m	Required torque, Nm	Peak acceleration*, rad/s ²
Option 1 (R1)	0.182	12.96	10711.5
Option 2 (R2)	0.150	16.77	15671.4
Option 3 (R3)	0.100	34.31	35350.0

* - calculated by multiplication of constant acceleration by $k = 1.85$