

Exercises with the maxon Selection Program

<http://www.maxonmotor.com/maxon/view/msp>

Purposes and Goals

The participants ...

- learn how to use the main parts of the maxon selection program.
- select motor-gearhead combinations for continuous and cyclic operation.
- select complete drive solutions for a positioning application.

Part 1: SEARCH - Easy drive specification with only a few parameters

The simple SEARCH functionality offers a fast way to find motor gearhead combinations for a fixed operation point. All you need to specify is a speed, a torque and a supply voltage. Additionally, you can limit the maximum diameter and opt for a sensor (encoder or tacho).

Exercise 1: Selection for continuous operation

Goal: Learn how the MSP works.

- Using the simple SEARCH function.
- Selecting solutions in the result list.
- Watching details of a specific solution.

Scanning device application



For a medical scanning device the motor gearhead combination typically has to run at 200 rpm at a torque of 150 mNm. The maximum power supply voltage is 18 VDC. There is a restriction on the diameter of 24mm and for speed control the motor needs to have an encoder.

-
1. Select the SEARCH tab.
Enter the parameters according to the application requirements. Since an encoder is needed, don't forget to select *with sensor*.

SEARCH
ADVANCED SEARCH

Easy drive specification with only a few parameters.
Hide details

Supply voltage	18	V	▼	Find solutions: <input checked="" type="radio"/> with sensor <input type="radio"/> without sensor
Max. load speed	200	min-1	▼	
rms load torque	0.15	Nm	▼	
Max. diameter	24	mm	▼	

Hint: The parameter inputs work as unit converters. A parameter value will be converted if the unit is changed. Therefore, for entering a specific value with a given unit select the unit first, and then enter the parameter value.

2. Result list.

Click on the *Show results* button on the lower right.

You will get a list of 10 propositions, each of them shortly described by the components it contains: Motor type, gearhead type and sensor type.

The default sorting of the list is according to the *Technical optimum*, i.e. solutions are preferred that make good use of the available voltage and torque (but still with some reserve power) and encoder with 500 counts per turn. It is instructive to set other priorities to your solution, such as smallest diameter, shortest length or lowest price. Setting other filters can be helpful in exploring all kind of other solutions. It's always the 10 best in class that are shown.

Select results filter

Technical optimum
 Shortest total length
 Lowest current consumption
 Smallest diameter
 Lowest total price (for 1-4 units)

// Results Technical optimum

Products	Technical data				Price	
	∅ [mm]	Length [mm]	Load [%]	Current [A]		
<div style="display: flex; align-items: center;"> <div style="margin-right: 10px;">▶</div> <div> <p>Motor EC-max 16 Gearhead GP 16 C, 29:1 Encoder MR, 128 cpt, LD, 3K</p> </div> </div>	16	56.5	81	0.51	CHF 440.50	Details
<div style="display: flex; align-items: center;"> <div style="margin-right: 10px; color: orange; font-weight: bold; font-size: 0.8em;">Configurable</div> <div> <p>Motor DCX 22 GB Gearhead GPX 22, 16:1 Encoder ENC 30 HEDL, 500 cpt, LD, 3K</p> </div> </div>	22	65.8	82	0.47	CHF 344.60	Details
<div style="display: flex; align-items: center;"> <div style="margin-right: 10px; color: orange; font-weight: bold; font-size: 0.8em;">Configurable</div> <div> <p>Motor DCX 22 GB Gearhead GPX 22, 16:1 Encoder ENC 30 HEDL, 500 cpt, LD,</p> </div> </div>	22	59.3	82	0.47	CHF 344.60	Details

3. Similar solutions.

Often, there are very similar solutions (e.g. made of the same motor type and gearhead type). In such cases only the best one is shown. You can make the alternative solutions visible by clicking on the triangle/arrow on the left. Typically, the *Similar solutions* contain units with different motor windings, different gearhead reductions, different current uptake or encoder counts.

// Results Shortest total length						
Products	Technical data				Price	
	∅ [mm]	Length [mm]	Load [%]	Current [A]		
▾ Motor EC-max 16 Gearhead GP 16 C, 29:1 Encoder MR, 512 cpt, LD, 2K	16	56.5	81	0.51	CHF 426.60 Details	
Similar solutions Hide details ▲						
Motor EC-max 16 Gearhead GP 16 C, 29:1 Encoder MR, 512 cpt, LD, 3K	16	56.5	81	0.51	CHF 440.50 Details	
Motor EC-max 16 Gearhead GP 16 C, 29:1 Encoder MR, 256 cpt, LD, 3K	16	56.5	81	0.51	CHF 440.50 Details	
Motor EC-max 16 Gearhead GP 16 C, 29:1 Encoder MR, 256 cpt, LD, 2K	16	56.5	81	0.51	CHF 426.60 Details	

4. *Details* button.

Select a solution and explore what's behind the *Details* button.

- Use the button *Print product detail*.
- Compare to the tab *Specification* (at the bottom).
- Look at the *Operating Range Diagram* of the combination in the corresponding tab.
- Explore the tab *Downloads*.

Details
[Hide details](#) ▲

Product consists of:

283834 - EC-max 16 Ø16 mm, brushless, 8 Watt

416428 - Planetary Gearhead GP 16 C Ø16 mm, 0.2 - 6 Nm 29:1

201937 - Encoder MR, Typ M, 512 CPT, 2 Channels, with Line Driver

[Add to wish list](#)

[Submit a request](#)

[Print product detail](#)

Price scales

Price per unit	1-4	CHF 426.60
	5-19	CHF 345.40
	20-49	CHF 274.50

Prices excluding VAT

Order quantity [Order](#)

Description
Specification
Downloads
Drive layout

Hint: The green *Order* button allows entering directly the shop area of the maxon website.

Part 2: ADVANCED SEARCH - Drive specification with high precision.

The ADVANCED SEARCH functionality allows to precisely specifying your application. You can define a mechanical transmission and enter the load speed and torque requirements in a more sophisticated matter. In addition the required control mode and accuracy can be stated.

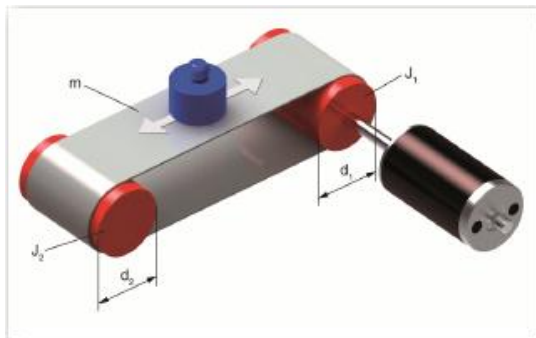
At the same time you can set filters on the product types you would like to have included in the search.

Exercise 2: Selection for continuous operation

Goal: Learn how the ADVANCED SEARCH works.

- Defining a mechanical transmission.
- Entering a continuous load.
- Selecting speed control with encoder.

Conveyor belt application



A motor gearhead combination is needed for a conveyor belt application running with a power supply of 24 VDC and 5 A.

In a first approximation the conveyor belt is assumed to run continuously at a maximum speed of 0.5 m/s.

The friction of the empty belt is 40 N. Additional friction due to the load (max. 3 kg) amounts to 9 N. Hence we have a total load of 49 N.

The belt is speed controlled, but the accuracy of speed control need not be very high.

The required life is quite high (several 10'000 hours), thus a brushless motor should be used.

1. Select the ADVANCED SEARCH tab.

The MSP will guide you through the different inputs and filters (buttons *Next* and *Back* at the bottom). We recommend that you use this input sequence.

Option: For direct access to the different settings in the drive specification, you can always click on the symbols in the drive system layout diagram at the top. The corresponding component is highlighted in the diagram.

2. Mechanical transmission.

The definition of the application requirements starts with the mechanical drive. From the drop down menu select *Conveyor belt* as the mechanical transmission.

For simplicity reasons we consider just the continuous operation and ignore the starting process. Therefore, we just need to enter the diameter of the pulleys and can neglect all the mass inertias. Let's assume that the driving pulley has a diameter of 10 cm.

Knowing the friction explicitly, we can add it to the load thrust force and can set efficiency to 100%.

YOUR DRIVE SYSTEM

LOAD

DRIVE

GEAR

MOTOR

SENSOR

CONTROL SYSTEM

POWER SUPPLY

SEARCH | ADVANCED SEARCH | SUMMARY

DRIVE - Specify the mechanical drive system with these parameters. Hide details

Select the mechanical drive layout i

Conveyor belt			
Motor pulley diameter	d1	100	mm
Diameter pulley	d2	100	mm
Efficiency		100.0	%
Inertia motor pulley	J1	0	gcm ²
Inertia pulley	J2	0	gcm ²
Conveyor mass	m	0	g

Reset | ← Back | Next → | Show results

3. Load definition.

Click on the *Next* button. The load specification window opens.

For continuous operation the inputs are straight forward. Enter the required load velocity and the load force (for our example 0.5 m/s and 49 N). (More sophisticated load situations will be treated in a later exercise)

Select operation type i

Continuous operation

Max. load speed	V _{max}	0.5	m/s
rms load force	F _{rms}	49	N

4. Gearhead and motor filter.

Click on the *Next* button. Specify whether the solution can or should contain a maxon gearhead or not. For our application we don't put any limits and leave the selection on *with or without gearhead*.

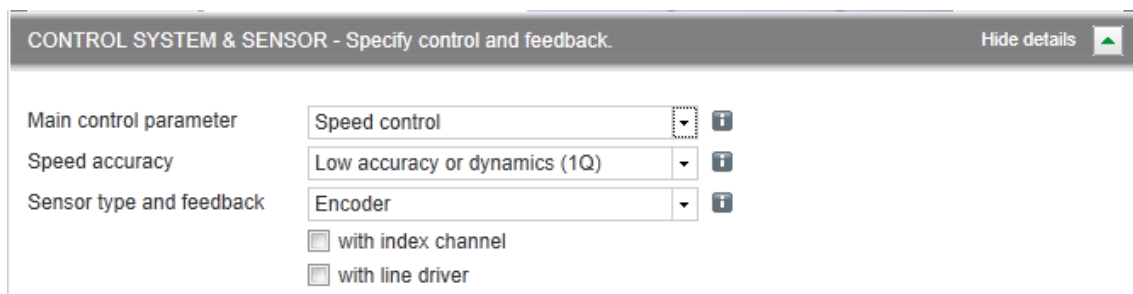
Click on the *Next* button. Specify whether the solution should contain a brushed maxon DC motor or a brushless maxon EC motor. Since we need a high operating life we select *with brushless motor (= maxon EC)*.

5. Boundary conditions.

Click on the *Next* button. There is no particular boundary and ambient conditions to be specified in our case. So, just click on the *Next* button again.

6. Control system.

Select *Speed control* as the *Main control parameter*, since the conveyer should run at constant speed. There is only a low speed accuracy and dynamics required, and we would like to use the encoder as a speed feedback device.



7. Power supply.

Click on the *Next* button. The available power supply just gives the 24 VDC and 5 A electrical power that are the default values in the MSP. So there is nothing to change.

8. Result list.

Click on the *Show results* button on the lower right.

The suggested drive solutions contain now the controller as well. Analyze the solutions and check the details as before in exercise 1.

Observe how the result list reacts if one of the inputs is changed: e.g. brushed motors instead of brushless motors, or high accuracy speed control.

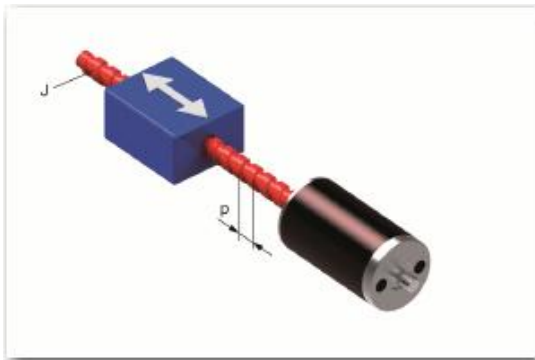
Remark: The *Similar Solutions* list contains now mainly alternative controllers and feedback sensors matching the required control. Motor and gearhead alternatives are not shown anymore.

Exercise 3: Selection for working cycles with positioning

Goal: Learn how *Cyclic or intermittent operation* works.

- Defining a mechanical transmission by lead screw.
- Entering a load cycle.
- Selecting position control with encoder.

Positioning with lead screw




A high precision lead screw with 2mm lead per revolution is used to position back and forth a device in a production plant with short dwell times in between the moves.


The rms average of the force needed (including dwell) is 23 N. The peak force is 44 N acting during 0.3 s acceleration. The maximum velocity is 100 mm/s.


There is a power supply of 48 VDC available that can deliver 1 A permanently and up to 2 A for about 1s.


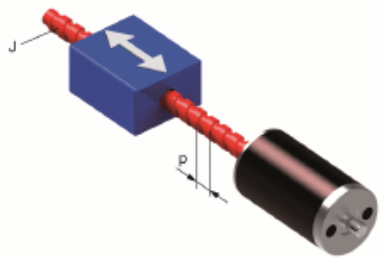



For life time reasons a brushless motor is required with a position controller. There is no gearhead (backlash!) allowed in order to achieve the position accuracy (repeatability) of 0.01 mm.

1. Select the ADVANCED SEARCH tab. Press the *Reset* button at the bottom.
2. Mechanical transmission.
From the drop down menu select *Spindle drive* as the mechanical transmission. Define the lead to be 2 mm and enter the efficiency. Ball screws typically have an efficiency around 90% or higher.
For a first selection we neglect all the mass inertias of the screw and the nut.
Click on the *Next* button.


DRIVE - Specify the mechanical drive system with these parameters. Hide details 


Select the mechanical drive layout 

Spindle drive 

Screw lead	p	2	mm		
Efficiency		90.0	%		
Screw inertia	J	0	gcm ²		
Nut mass		0	g		

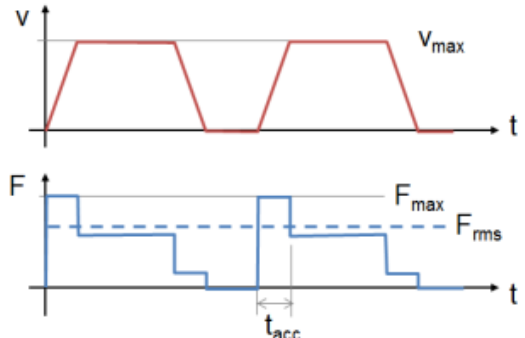
3. Load definition
From the drop down menu select *Cyclic and intermittent operation*. Then fill in the input fields according to the requirements of the application.

LOAD - Specify your load requirements. Hide details 

Select operation type 

Cyclic or intermittent operation ▼

Max. load speed	Vmax	0.1	m/s	▼
rms load force	Frms	23	N	▼
Max. load force	Fmax	44	N	▼
Acceleration time	tacc	0.2	s	▼
Positioning accuracy		0.01	mm	▼



Click on the *Next* button.

4. Gearhead and motor filter.

Specify now that you are only interested in solutions without gearheads and motors without brushes.

Click on the *Next* button.


5. Boundary conditions.




There is no particular boundary and ambient conditions to be specified in our case. So, just click on the *Next* button again.

6. Control system.

Select *Position control* as the control parameter.

The accuracy required is about $0.01\text{mm}/2\text{mm} = 1/200$ motor turn (or 1.8°). Hence we need a position sensor (encoder) that has at least 200 counts per turn. This is still average accuracy. The encoder should exhibit a Line Driver for reliable position signals and an Index channel to get a precise position reference.

CONTROL SYSTEM & SENSOR - Specify control and feedback. Hide details 

Main control parameter	Position control	▼	
Positioning accuracy	Average accuracy ($1^\circ \dots 10^\circ$)	▼	
Sensor type and feedback	Encoder	▼	

with index channel

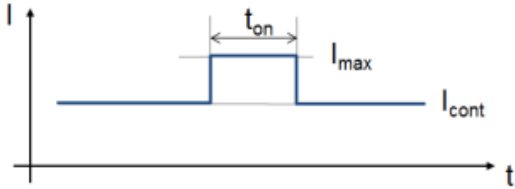
with line driver

7. Power supply.

Click on the *Next* button. Adjust the parameters according to the power supply capabilities at hand.

POWER SUPPLY – Specify. Hide details

Supply voltage		48	V	
Continuous current	ICont	1	A	
Max. current	I _{max}	2	A	
Duration of max. current	t _{on}	1	s	



8. Summary.

Click on the *SUMMARY* tab on the right and check your inputs. In the *Key parameters* section you can find the requirements for the drive to be selected.

Look at the torque values and the moment of inertia. Now, click on the *DRIVE* symbol in the diagram and change the mass inertia of the screw to 3 gcm² and the nut mass to 1000 g (here including load mass). Observe in the *SUMMARY* tab how the torque and inertia values have changed.

SEARCH
ADVANCED SEARCH
SUMMARY

SUMMARY - Your entered parameters and key parameters for the selection are: Hide details

<p>→ Load - Cyclic or intermittent operation</p> <table style="width: 100%; border-collapse: collapse;"> <tr><td>Max. load speed</td><td>0.1 m/s</td></tr> <tr><td>rms load force</td><td>23 N</td></tr> <tr><td>Max. load force</td><td>44 N</td></tr> <tr><td>Acceleration time</td><td>0.2 s</td></tr> <tr><td>Positioning accuracy</td><td>0.01 mm</td></tr> </table> <p>→ Drive - Spindle drive</p> <table style="width: 100%; border-collapse: collapse;"> <tr><td>Screw lead</td><td>2 mm</td></tr> <tr><td>Efficiency</td><td>90 %</td></tr> <tr><td>Screw inertia</td><td>3 gcm²</td></tr> <tr><td>Nut mass</td><td>1000 g</td></tr> </table> <p>→ Gearhead</p> <p>without maxon gearhead</p> <p>→ Motor</p> <p>with brushless motor (= maxon EC)</p>	Max. load speed	0.1 m/s	rms load force	23 N	Max. load force	44 N	Acceleration time	0.2 s	Positioning accuracy	0.01 mm	Screw lead	2 mm	Efficiency	90 %	Screw inertia	3 gcm ²	Nut mass	1000 g	<p>→ Control System - Position control</p> <table style="width: 100%; border-collapse: collapse;"> <tr><td>Positioning accuracy</td><td>Average accuracy (1° ...</td></tr> <tr><td>Sensor type and feedback</td><td>Encoder</td></tr> <tr><td>with index channel</td><td>Yes</td></tr> <tr><td>with line driver</td><td>Yes</td></tr> </table> <p>→ Power supply</p> <table style="width: 100%; border-collapse: collapse;"> <tr><td>Supply voltage</td><td>48 V</td></tr> <tr><td>Continuous current</td><td>1 A</td></tr> <tr><td>Max. current</td><td>2 A</td></tr> <tr><td>Duration of max. current</td><td>1 s</td></tr> </table> <p>→ Boundary and ambient conditions</p> <table style="width: 100%; border-collapse: collapse;"> <tr><td>Max. ambient temperature</td><td>25 °C</td></tr> <tr><td>Min. ambient temperature</td><td>0 °C</td></tr> <tr><td>Max. permissible installation length</td><td>of any length</td></tr> <tr><td>Max. diameter</td><td>of any diameter</td></tr> <tr><td>Sterilizable/autoclavable</td><td>No</td></tr> </table> <p>Key parameters</p> <table style="width: 100%; border-collapse: collapse;"> <tr><td>Max. speed</td><td>3000 min⁻¹</td></tr> <tr><td>Continuous torque (rms)</td><td>8.13 mNm</td></tr> <tr><td>Max. torque</td><td>16.2 mNm</td></tr> <tr><td>Duration of max. load</td><td>0.2 s</td></tr> <tr><td>Moment inertia</td><td>4.13 gcm²</td></tr> <tr><td>Positioning accuracy</td><td>1.8 grad</td></tr> </table>	Positioning accuracy	Average accuracy (1° ...	Sensor type and feedback	Encoder	with index channel	Yes	with line driver	Yes	Supply voltage	48 V	Continuous current	1 A	Max. current	2 A	Duration of max. current	1 s	Max. ambient temperature	25 °C	Min. ambient temperature	0 °C	Max. permissible installation length	of any length	Max. diameter	of any diameter	Sterilizable/autoclavable	No	Max. speed	3000 min ⁻¹	Continuous torque (rms)	8.13 mNm	Max. torque	16.2 mNm	Duration of max. load	0.2 s	Moment inertia	4.13 gcm ²	Positioning accuracy	1.8 grad
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9. Result list.

Click on the *Show results* button on the lower right.

The suggested drive solutions contain now position controller. Analyze the solutions and check the details as before in exercise 1 and 2.

Exercise 4: Selection for Short-term operation

Goal: Lear how *Short-term operation* works.

- Defining a direct drive
- Entering a "once in a while" load
- Selecting speed control with encoder

Flywheel acceleration



A flywheel needs to be accelerated in 7 s to a speed of 17'000 rpm. This requires a torque of about 60 mNm. The available voltage is 24V.

Space is limited: The maximum diameter is 1 inch and the length should not be as short as possible (max. 2 inches).

Drive components needed: Motor with feedback and speed controller.

1. Select the ADVANCED SEARCH tab.

Press the *Reset* button at the bottom.

There is no mechanical transmission to be selected.

2. Load definition.

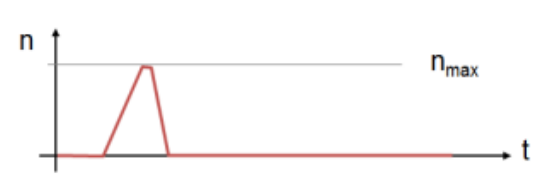
From the drop down menu select *Short-term operation*. Fill in the input fields according to the requirements of the application. Click on the *Next* button.

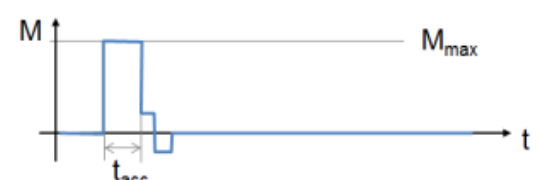
LOAD - Specify your load requirements. Hide details

Select operation type

Short-term operation ▼

Max. load speed	nmax	17000	min-1	▼
Max. load torque	Mmax	60	mNm	▼
Acceleration time	tacc	7	s	▼
Positioning accuracy			grad	▼





3. Specify the gearhead and motor filters.

Note: The high speed makes it highly improbable that any gearheads or brushed motors are selected.

4. Boundary conditions.

Limit the maximum diameter to 2 inches and the maximum length to 3 inches.

5. Control system.

Select *Speed control* with high dynamics.

6. Power supply.

Try the default power supply values. The electrical power capabilities might be a little low as can be seen from a power comparison:

- Required mechanical power: approx. 100 W (= $\pi/30 * 17 \text{ krpm} * 60 \text{ mNm}$)
- Available electrical power (> 7 s) approx. 120 W (= $24 \text{ V} * 5 \text{ A}$)

7. Result list.

As almost expected, the power is too low and there are no solutions found. Hence, click on the *POWER SUPPLY* in the diagram and allow for higher continuous current or more supply voltage. Recommendation: Double the voltage (In this case this is the strongest restriction).

Analyze the solutions and check the details as in the exercises before.