

## Exercises with the maxon Selection Program

<http://www.maxongroup.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 must 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 24 mm 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*.

## Maxon Selection Program

**YOUR DRIVE SYSTEM**

LOAD DRIVE GEARHEAD MOTOR SENSOR CONTROL SYSTEM POWER SUPPLY

BOUNDARY & AMBIENT CONDITIONS

SEARCH ADVANCED SEARCH

Easy drive specification with only a few parameters. Hide details

Supply voltage

Max. load speed

rms load torque

Max. diameter

**Find solutions:**

with sensor

without sensor

**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							
<input checked="" type="radio"/>	Technical optimum	<input type="radio"/>	Shortest total length	<input type="radio"/>	Lowest current consumption		
<input type="radio"/>	Smallest diameter	<input type="radio"/>	Lowest total price (for 1-4 units)				
// Results Technical optimum							
Products	Technical data				Price		
		ø [mm]	Length [mm]	Load [%]	Current [A]		
	Motor <b>EC-max 16</b> Gearhead <b>GP 16 C</b> , 29:1 Encoder <b>MR</b> , 512 cpt, LD, 2°K	16	59.3	81	0.50	<b>EUR 381.55</b>	<a href="#">Details</a>
	<span>Configurable</span> <span>new</span> Motor <b>DCX 22 L GB</b> Gearhead <b>GPX 22 LN</b> , 6.6:1 Encoder <b>ENC 30 HEDL</b> , 500 cpt, LD, 3°K	22	67.2	83	0.57	<b>EUR 346.09</b>	<a href="#">Details</a>
	<span>Configurable</span> Motor <b>DCX 22 L GB</b> Gearhead <b>GPX 22 LN</b> , 6.6:1 Encoder <b>HEDS</b> , 500 cpt, 3°K	22	67.2	83	0.57	<b>EUR 333</b>	<a href="#">Details</a>
	<span>Configurable</span> Motor <b>DCX 14 L GB</b> Gearhead <b>GPX 14</b> , 35:1 Encoder <b>ENX 10 QUAD</b> , 1 cpt, 2°K	14	56.5	78	0.39	<b>EUR 226.18</b>	<a href="#">Details</a>

### 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.

	<span>Configurable</span> Motor <b>DCX 14 L GB</b> Gearhead <b>GPX 14</b> , 35:1 Encoder <b>ENX 10 QUAD</b> , 1 cpt, 2°K	14	56.5	78	0.39	<b>EUR 226.18</b>	<a href="#">Details</a>
Similar solutions <span style="float: right;">Hide details </span>							
	<span>Configurable</span> Motor <b>DCX 14 L GB</b> Gearhead <b>GPX 14</b> , 35:1 Encoder <b>ENX 10 EASY</b> , 1024 cpt, LD, 3°K	14	56.5	78	0.39	<b>EUR 273.45</b>	<a href="#">Details</a>
	<span>Configurable</span> <span>new</span> Motor <b>DCX 14 L GB</b> Gearhead <b>GPX 14</b> , 35:1 Encoder <b>ENX 10 EASY XT</b> , 1024 cpt, 3°K	14	56.5	78	0.39	<b>EUR 336.55</b>	<a href="#">Details</a>
	<span>Configurable</span> Motor <b>DCX 14 L GB</b> Gearhead <b>GPX 14</b> , 35:1 Encoder <b>ENX 10 EASY</b> , 512 cpt, LD, 3°K	14	56.5	78	0.39	<b>EUR 273.45</b>	<a href="#">Details</a>
	<span>Configurable</span> Motor <b>DCX 14 L GB</b>						

#### 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*.

The screenshot shows a product details window titled "Details" with a "Hide details" button in the top right. The main content area is divided into several sections:

- Product consists of:** A list of three components:
  - 283834** - EC-max 16 Ø16 mm, brushless, 8 Watt, with Hall sensors
  - 416428** - Planetary Gearhead GP 16 C Ø16 mm, 0.2–0.6 Nm 29:1
  - 201937** - Encoder MR, Type M, 512 CPT, 2 Channels, with Line Driver
- Action buttons:** Three buttons with icons: "Add to wish list", "Submit a request", and "Print product detail".
- Price scales:** A table showing price per unit for different quantities.

Price per unit	Quantity	Price
	1-4	EUR 381.55
	5-19	EUR 308.82
	20-49	EUR 245.36
	from 50	On request
- Ordering:** An "Order quantity" input field set to "1" and a green "Add to cart" button with a shopping cart icon.
- Navigation tabs:** Four tabs at the bottom: "Description" (selected), "Specification", "Downloads", and "Drive layout".

**Hint:** The green "Add to cart" button allows entering directly the shop area of the maxon website.

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

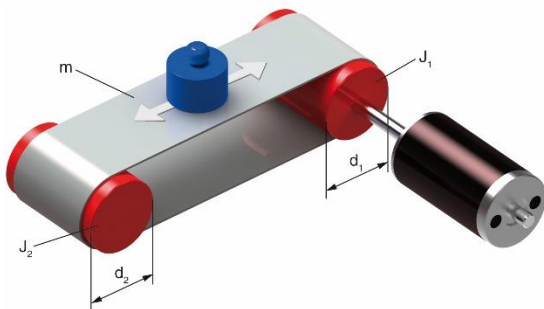
The ADVANCED SEARCH functionality allows to precisely specify your application. You can define a mechanical transmission and enter the load speed and torque requirements in a more sophisticated matter. In addition, the required control mode and accuracy can be stated. At the same time, you can set filters 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%.

## Maxon Selection Program

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

Select the mechanical drive layout

Conveyor belt

Motor pulley diameter  $d_1$  100 mm

Diameter pulley  $d_2$  100 mm

Max. efficiency 100.0 %

Inertia motor pulley  $J_1$  gcm<sup>2</sup>

Inertia pulley  $J_2$  gcm<sup>2</sup>

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).

LOAD - Specify your load requirements. Hide details

Select operation type

Continuous operation

Max. load speed  $V_{max}$  0.5 m/s

rms load force  $F_{rms}$  49 N

$v$  vs  $t$  graph showing  $V_{max}$

$F$  vs  $t$  graph showing  $F_{rms}$

#### 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 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.

CONTROL SYSTEM & SENSOR - Specify control and feedback Hide details 

Main control parameter	<input type="text" value="Speed control"/> 
Speed accuracy	<input type="text" value="Low accuracy or dynamics"/> 
Sensor type and feedback	<input type="text" value="Encoder"/> 
	<input type="checkbox"/> with index channel
	<input type="checkbox"/> with line driver

#### 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.

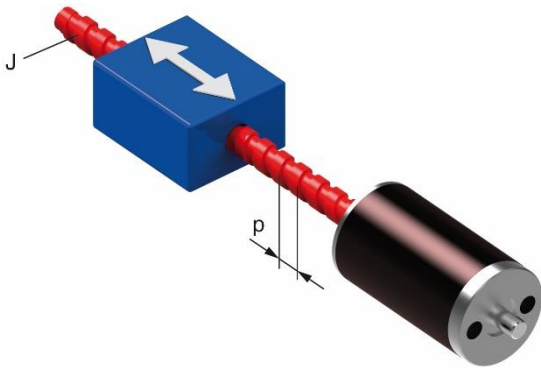
**Remark:** The *Similar Solutions* list contains now mainly alternative controllers and feedback sensors matching the required control. Motor and gearhead alternatives are not shown anymore.

## 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 dropdown 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	▼
Max. efficiency		90.0	%	▼
Screw inertia	J	0	gcm <sup>2</sup>	▼
Nut mass		0	g	▼



### 3. Load definition

From the dropdown 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** i

Cyclic or intermittent operation ▼

Max. load speed	Vmax	100	mm/s	▼
rms load force	Frms	23	N	▼
Max. load force	Fmax	44	N	▼
Acceleration time	tacc	0.3	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 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  $1.8^\circ$ ). 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	▼	i
Positioning accuracy	Average accuracy ( $1^\circ \dots 10^\circ$ )	▼	i
Sensor type and feedback	Encoder	▼	i
	<input checked="" type="checkbox"/> with index channel		
	<input checked="" type="checkbox"/> with line driver		

## 7. Power supply

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

POWER SUPPLY – Specify. Hide details ▲

Supply voltage	Vcc	<input type="text" value="48"/>	V	▼
Continuous current	ICont	<input type="text" value="1"/>	A	▼
Max. current	I <sub>max</sub>	<input type="text" value="2"/>	A	▼
Duration of max. current	t <sub>on</sub>	<input type="text" value="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 gcm<sup>2</sup> 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 border="0"> <tr><td>Max. load speed</td><td>100 mm/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>0.3 s</td></tr> <tr><td>Positioning accuracy</td><td>0.01 mm</td></tr> </table>	Max. load speed	100 mm/s	rms load force	23 N	Max. load force	44 N	Acceleration time	0.3 s	Positioning accuracy	0.01 mm	<p>→ Control System - Position control</p> <table border="0"> <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>	Positioning accuracy	Average accuracy (1° ...	Sensor type and feedback	Encoder	with index channel	Yes	with line driver	Yes
Max. load speed	100 mm/s																		
rms load force	23 N																		
Max. load force	44 N																		
Acceleration time	0.3 s																		
Positioning accuracy	0.01 mm																		
Positioning accuracy	Average accuracy (1° ...																		
Sensor type and feedback	Encoder																		
with index channel	Yes																		
with line driver	Yes																		
<p>→ Drive - Spindle drive</p> <table border="0"> <tr><td>Screw lead</td><td>2 mm</td></tr> <tr><td>Max. efficiency</td><td>90 %</td></tr> <tr><td>Screw inertia</td><td>3 gcm<sup>2</sup></td></tr> <tr><td>Nut mass</td><td>1000 g</td></tr> </table>	Screw lead	2 mm	Max. efficiency	90 %	Screw inertia	3 gcm <sup>2</sup>	Nut mass	1000 g	<p>→ Power supply</p> <table border="0"> <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>	Supply voltage	48 V	Continuous current	1 A	Max. current	2 A	Duration of max. current	1 s		
Screw lead	2 mm																		
Max. efficiency	90 %																		
Screw inertia	3 gcm <sup>2</sup>																		
Nut mass	1000 g																		
Supply voltage	48 V																		
Continuous current	1 A																		
Max. current	2 A																		
Duration of max. current	1 s																		
<p>→ Gearhead</p> <p>without maxon gearhead</p>	<p>→ Boundary and ambient conditions</p> <table border="0"> <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. 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>	Max. ambient temperature	25 °C	Min. ambient temperature	0 °C	Max. installation length	of any length	Max. diameter	of any diameter	Sterilizable/autoclavable	No								
Max. ambient temperature	25 °C																		
Min. ambient temperature	0 °C																		
Max. installation length	of any length																		
Max. diameter	of any diameter																		
Sterilizable/autoclavable	No																		
<p>→ Motor</p> <p>with brushless motor (= maxon EC)</p>	<p>Key parameters</p> <table border="0"> <tr><td>Max. speed</td><td>3000 1/min</td></tr> <tr><td>Continuous torque (rms)</td><td>8.13 mNm</td></tr> <tr><td>Max. torque</td><td>16 mNm</td></tr> <tr><td>Duration of max. load</td><td>0.3 s</td></tr> <tr><td>Mass inertia</td><td>4.13 gcm<sup>2</sup></td></tr> <tr><td>Positioning accuracy</td><td>1.8 Grad</td></tr> </table>	Max. speed	3000 1/min	Continuous torque (rms)	8.13 mNm	Max. torque	16 mNm	Duration of max. load	0.3 s	Mass inertia	4.13 gcm <sup>2</sup>	Positioning accuracy	1.8 Grad						
Max. speed	3000 1/min																		
Continuous torque (rms)	8.13 mNm																		
Max. torque	16 mNm																		
Duration of max. load	0.3 s																		
Mass inertia	4.13 gcm <sup>2</sup>																		
Positioning accuracy	1.8 Grad																		

## 9. Result list

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

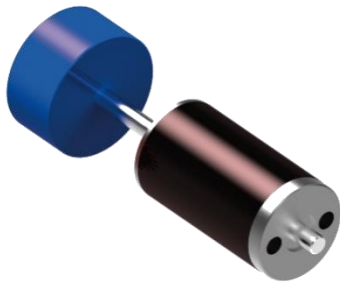
The suggested drive solutions contain now position controller. Analyze the solutions and check the details as before in exercise 1 and 2.

## Exercise 4: Selection for Short-term operation

Goal: Learn 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 dropdown 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 i  
Short-term operation

Max. load speed  $n_{max}$   rpm

Max. load torque  $M_{max}$   mNm

Acceleration time  $t_{acc}$   s

Positioning accuracy  degree

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. Power supply

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.