Cartesian Robotic Manipulator
MSc Project Report
University of Debrecen, 2023

Mohammad Alghazawi

1. Description of the machine's kinematic chain and Calculation of the degrees of freedom of the mechanism

Task Data:

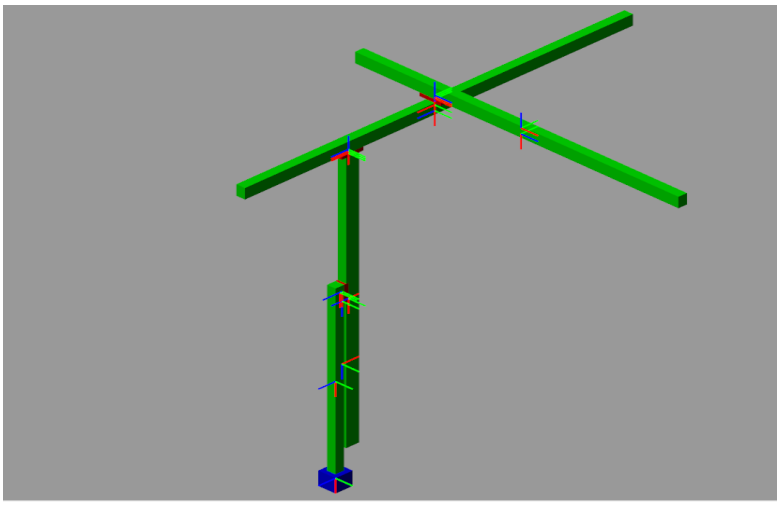
- X displacement (mm): 350
- Y displacement (mm): 350
- Z displacement (mm): 250
- Mass (kg): 7
- Cycle time (s): 22

Trajectory: 01A2B3C4

Degrees of freedom = 3(n-1) – 2Jp

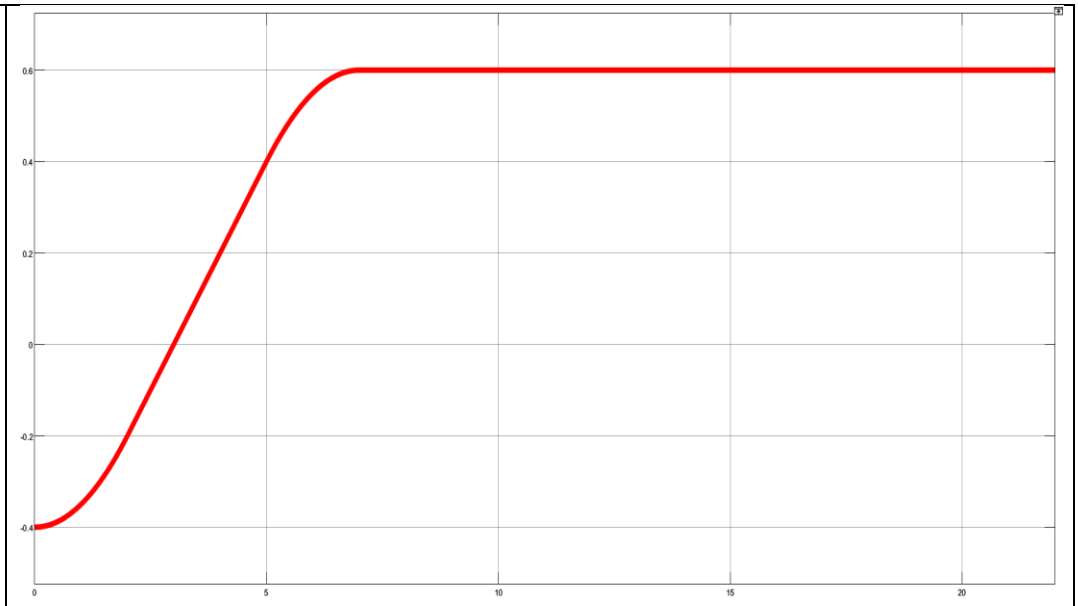
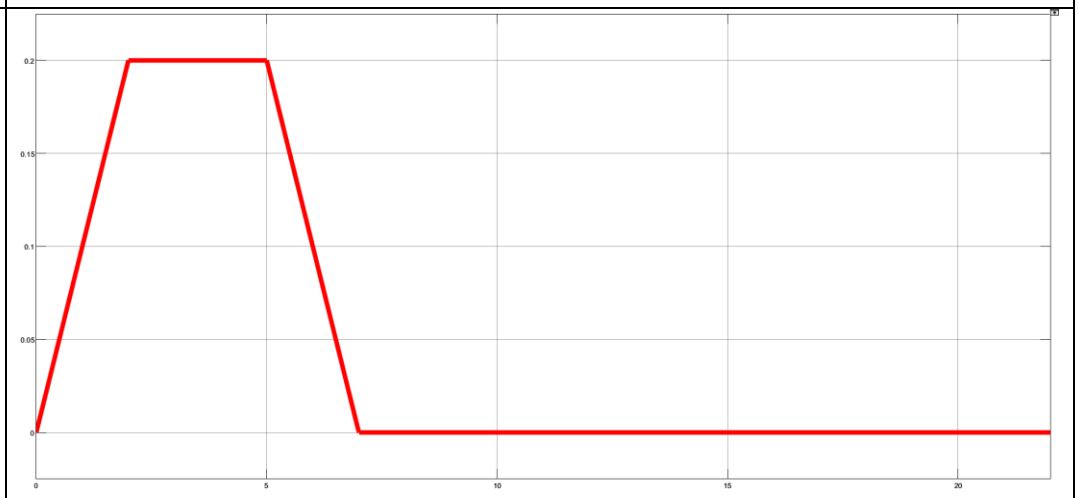
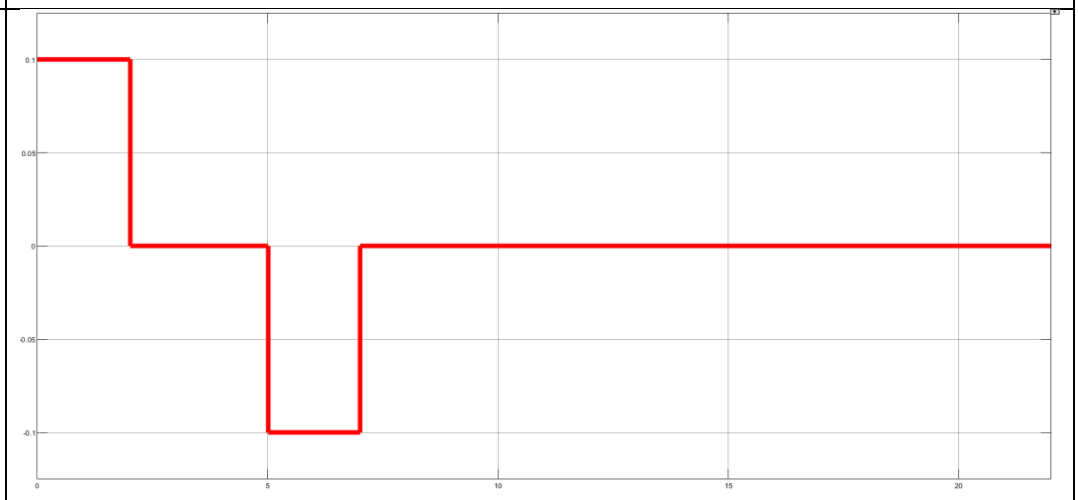
= 3(4-1) – 2*3

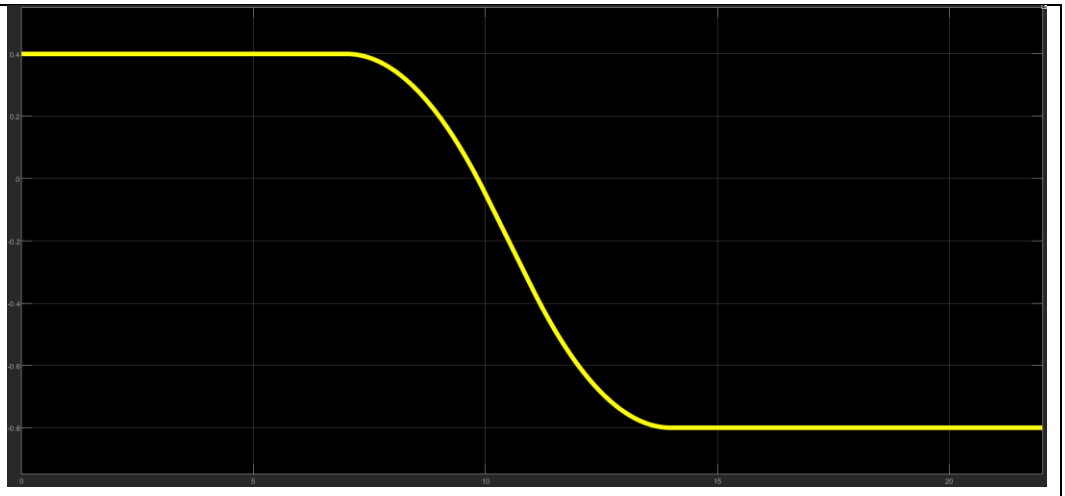
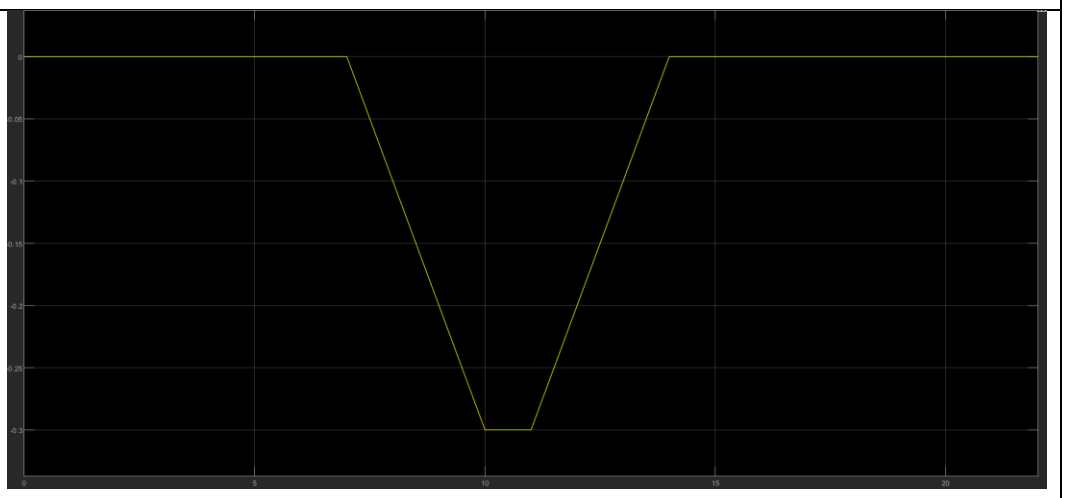
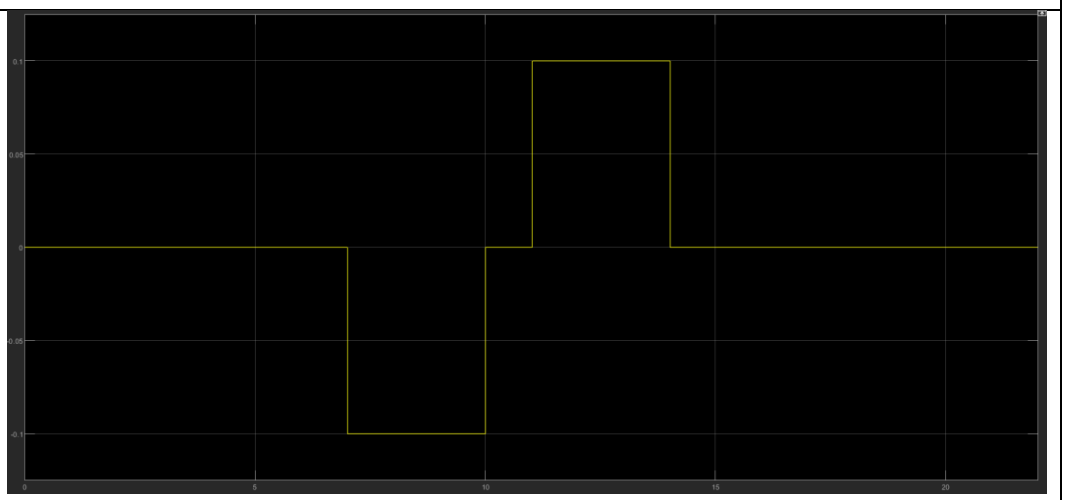
= 3DoF

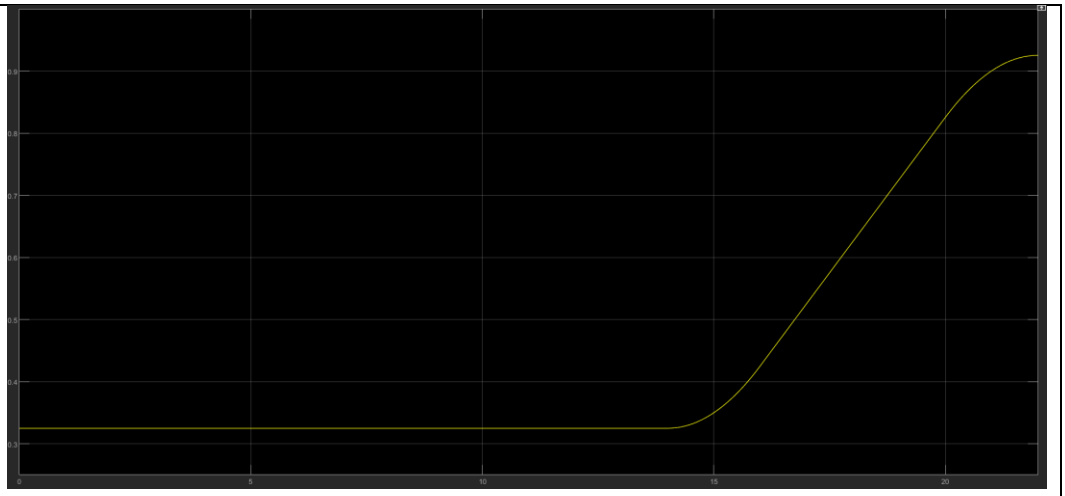
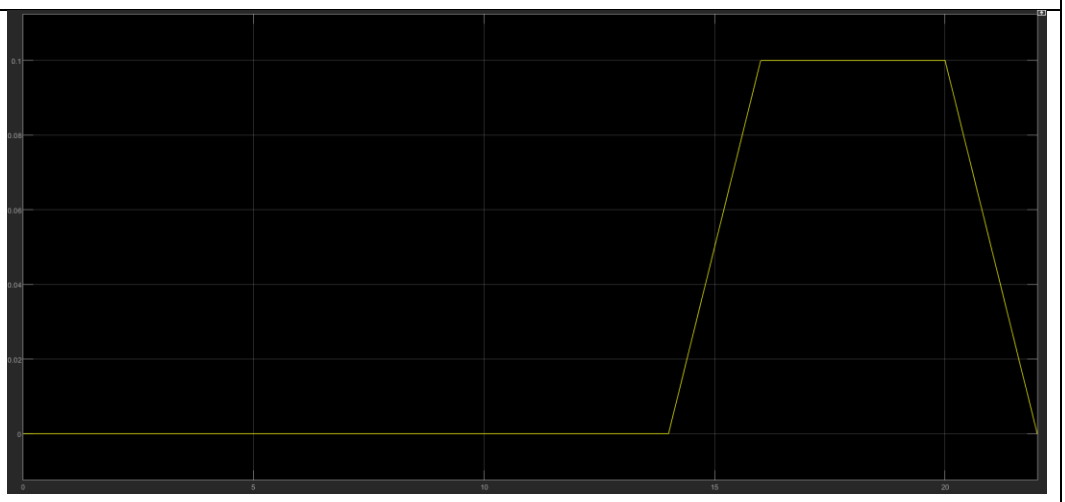
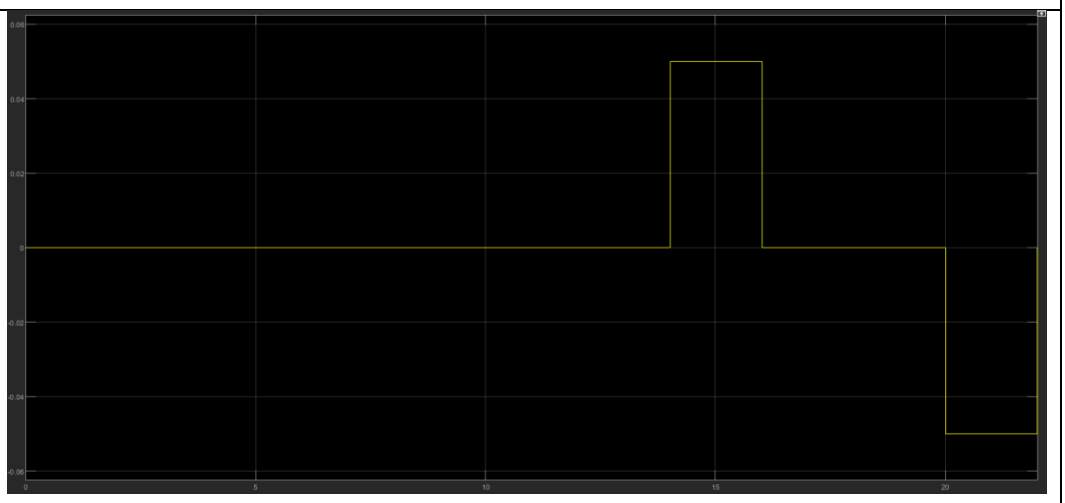


2. Displacement vs. time, velocity vs. time. acceleration vs. time functions for the motion of the 3 axes

X-axis

Position	
Velocity	
Acceleration	
Y-axis	

Position	
Velocity	
Acceleration	
Z-axis	

Position	
Velocity	
Acceleration	

3. Hartenberg-Denavit parameters

$$\begin{bmatrix} Cos\theta & -sin\theta cos\alpha & sin\theta sin\alpha & r * cos\theta \\ sin\theta & cos\theta cos\alpha & -cos\theta sin\alpha & r * sin\theta \\ 0 & sin\alpha & cos\alpha & d \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

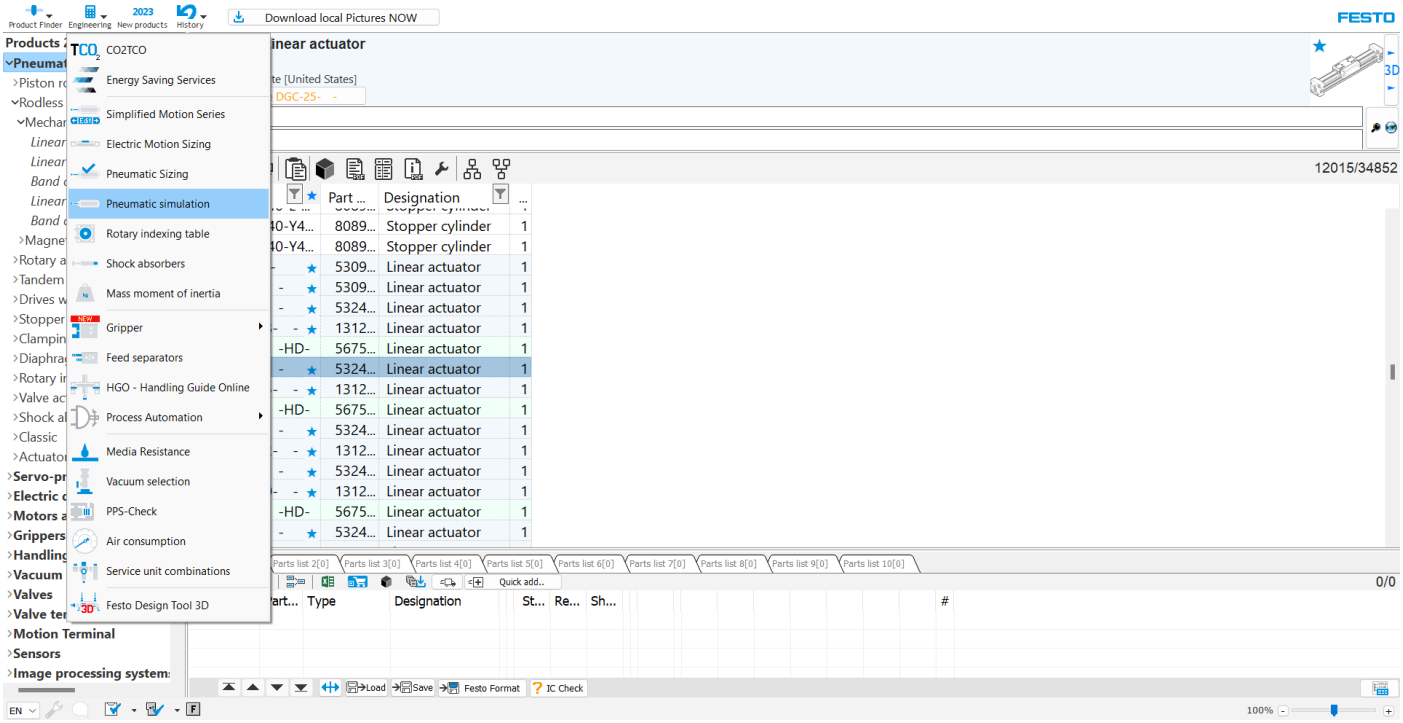
Joint Number	Joint Type	Joint offset (d) mm	Joint angle (Theta) deg	Link length (r) mm	Twist Angle (alpha) deg
0	Prismatic	0	0	350	0
1	Prismatic	350	0	0	90
2	Prismatic	-250	-90	0	90
3	Prismatic	462.1	-90		90

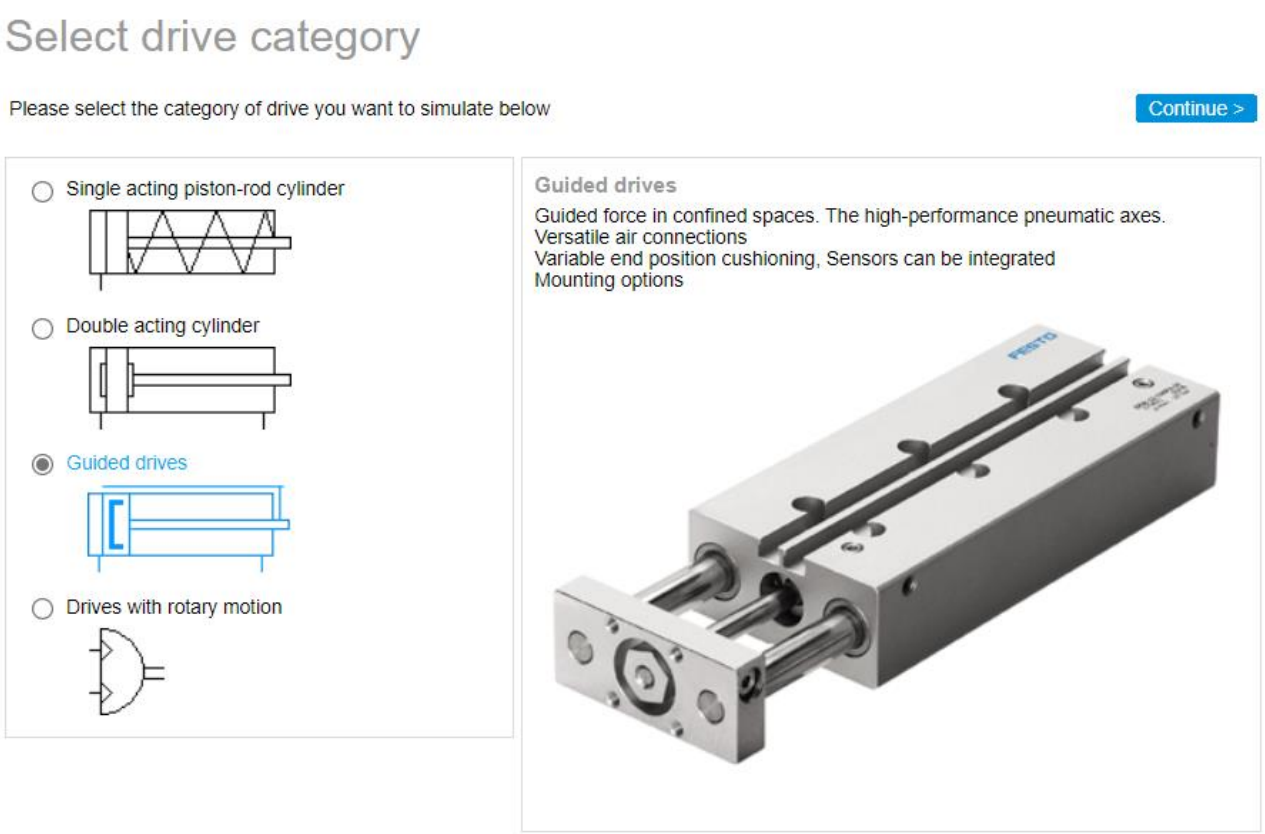
$$\begin{bmatrix} 1 & 0 & 0 & 350 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 0 & -1 & 0 \\ 0 & 1 & 0 & 350 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 0 & 0 & -1 & 0 \\ -1 & 0 & 0 & 0 \\ 0 & 1 & 1 & -250 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 462.1 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$= \begin{bmatrix} 0 & 0 & -1 & -112.1 \\ 0 & -1 & 0 & 250 \\ -1 & 0 & 1 & 350 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

4. Choose the applicable mechanic, servo-electric, servo-pneumatic equipment! You can use the „Positioning drives” application.
   You can place the required screen-shots into the documentation.

I. For Z-axis:

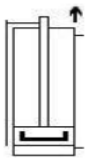




1. System parameters | 2. Cylinder selection | 3. System | 4. Simulation | 5. Bill of materials

System parameters - Select main settings here.

Continue >



Desired positioning time	Try to achieve an positioning time of exactly:		8 s
	☐ with throttle valve		
Initial cylinder parameters	Required stroke		250 mm
	Axial mounting angle		90 deg
	Radial mounting angle		0 deg
	Direction of movement		◉ Extend ○ Retract
Air supply and tubing	Air supply pressure		6 bar
	Tubing length	Air supply > valve	1 m
		Valve > cylinder	1 m
Load settings	Moving mass		7 kg
	Additional thrust		0 lbf
	Additional friction		0 lbf

Continue >

1. System parameters | 2. Cylinder selection | 3. System | 4. Simulation | 5. Bill of materials

Festo pneumatic cylinders - a wealth of ideas

- ☐ Adjustable end position cushioning (PPV) ONLY
- ☑ Rodless linear actuators ONLY
- ☐ Double ended piston rod (S2) ONLY
- ☐ Non-rotating ONLY
- ☐ only in Required stroke 250 [mm]
- ☐ only in Variable stroke length

Selected piston diameter - all -

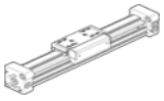
< Back | Continue >

Items found [72] | Show 10

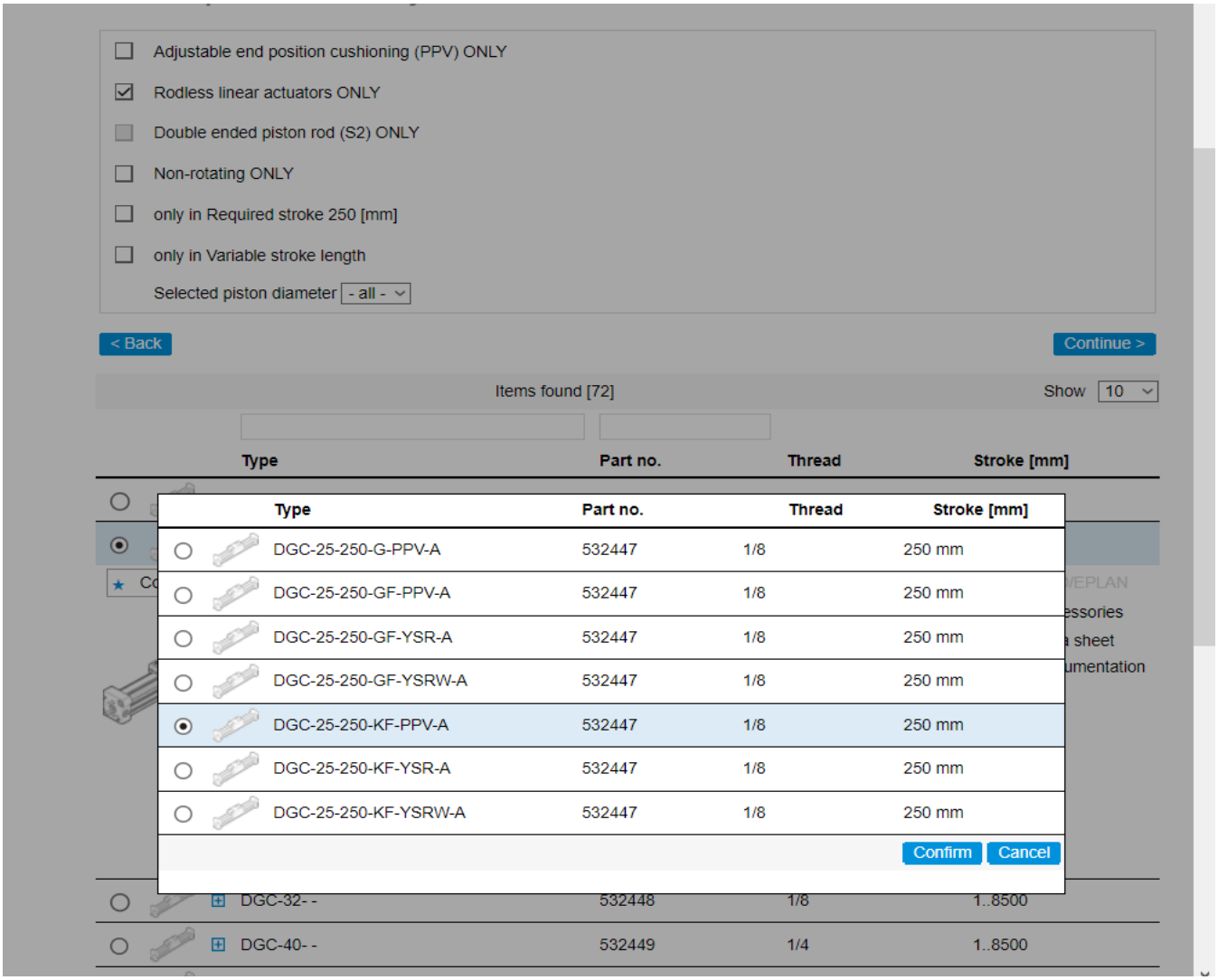
	Type	Part no.	Thread	Stroke [mm]
○	⊞ DGC-18- -	532446	M5	1..3000
○	⊟ DGC-25- -	532447	1/8	1..8500

★ Core product range

CAD/EPLAN
Accessories
Data sheet
Documentation



Other stroke lengths upon request. Refer to the catalog pages (PDF) for the characteristic load values.



Tubing and fittings - essential for all pneumatic systems

Tubing [Cyl. > Valve]

Material PUN
Color BLUE
Tube diameter 6
Food industry approval

< Back
Continue >

Items found [4]
Show 10

Type	Part no.	Color	Tube diameter
PUN-6x1-BL	159664	BLUE	6
PUN-6x1-BL-500	525747	BLUE	6
PUN-H-6x1-BL	197384	BLUE	6
PUN-V0-6x1-BL	525442	BLUE	6

1

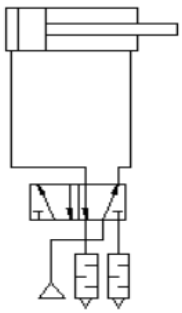
Fittings

	Type	Part no.	Thread	Series
Fitting for ..on the cylinder	QS-G1/8-6-I	186107	1/8	QS
An adapter is required!				
Fitting for Valve	QS-G1/8-6-I	186107	1/8	QS

< Back
Continue >

1. System parameters | 2. Cylinder selection | 3. System | 4. Simulation | 5. Bill of materials

Valve/tube/fittings selection System simulation



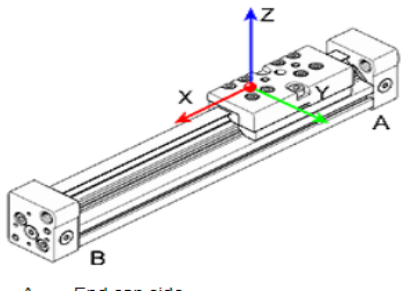
PPV settings
100 %

Please select the component(s) by clicking on the corresponding label or image below.

	Cylinder	DGC-25-250-KF-PPV-A
☐	Shock absorber	
	Tubing [Cyl. > Valve] An adapter is required!	PUN-4x0,75-BL (1 m)
	Valve	VUVG-L14-B52-ZT-G18-1P3
	Tubing [air supply > valve]	PUN-4x0,75-BL (1 m)
	Silencer	U -1/8

Air supply pressure: 6 bar

Direction of movement: ◉ Extend ○ Retract ☐ full sequence cycle



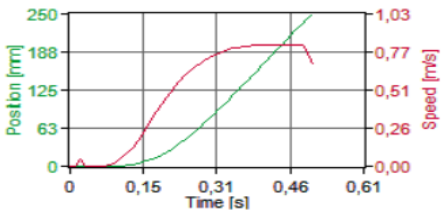
Set load details for moment calculation

Single mass: 7 kg

Lever arms: X 0 ft; Y 0 ft; Z 0 ft

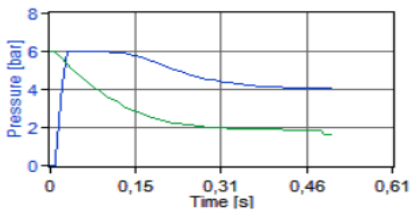
< Back | Continue >

position/speed/time diagram

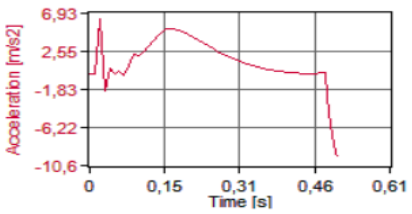


Total positioning time	0.503 s
Average speed	0.530 m/s
Impact speed	0.688 m/s
Max. speed	0.825 m/s
Kinetic impact energy	1.830 J
Air Consumption per Cycle	1.962 l
PPV settings	100 %

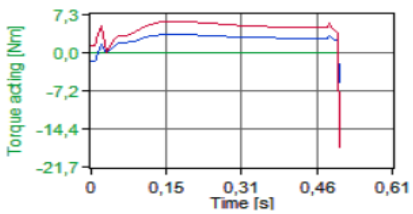
pressure/time diagram



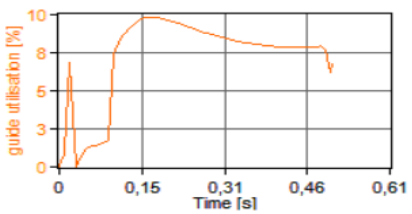
acceleration/time diagram



Torque/time diagram



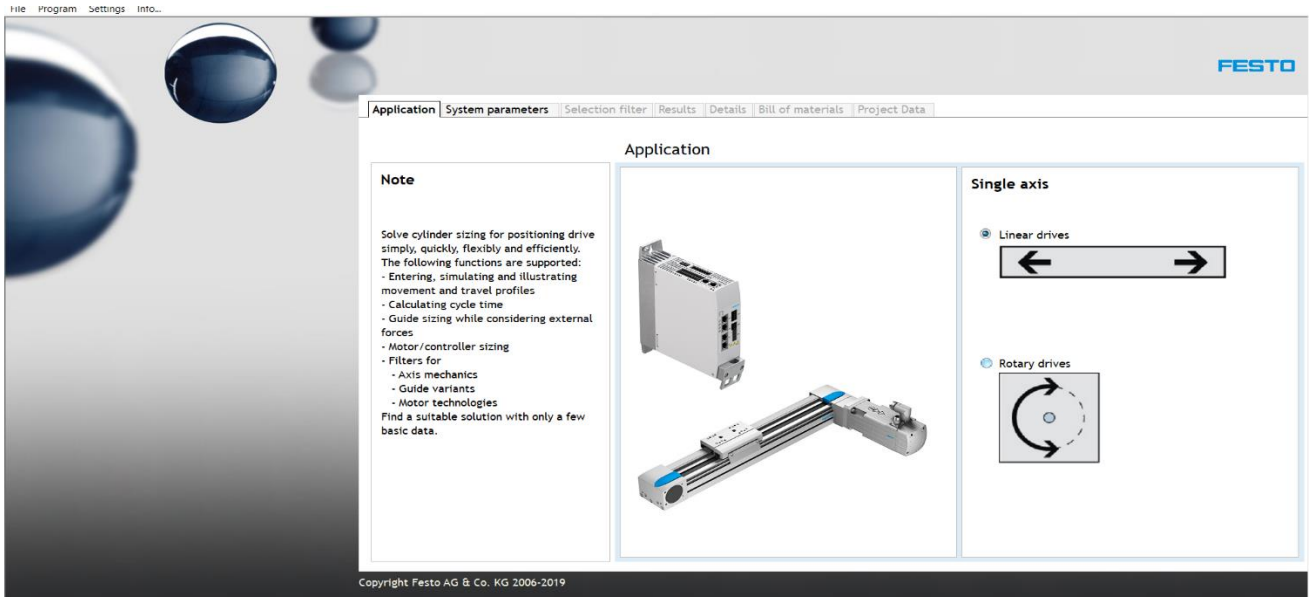
guide utilisation/time diagram



GSED Simulation feedback, Details and tips regarding simulation results

- Cylinder 1 overloaded by more than 50%. Maximum residual energy at bearing cap exceeded. Service life substantially reduced.
- No stable end position (acceleration) with cylinder 1. Cylinder can spring back.

II. For Y-axis


File Program Settings Info...
FESTO
Application System parameters Selection filter Results Details Bill of materials Project Data
Application
Note
Solve cylinder sizing for positioning drive simply, quickly, flexibly and efficiently.
The following functions are supported:
- Entering, simulating and illustrating movement and travel profiles
- Calculating cycle time
- Guide sizing while considering external forces
- Motor/controller sizing
- Filters for
- Axis mechanics
- Guide variants
- Motor technologies
Find a suitable solution with only a few basic data.
Single axis
Linear drives
Rotary drives
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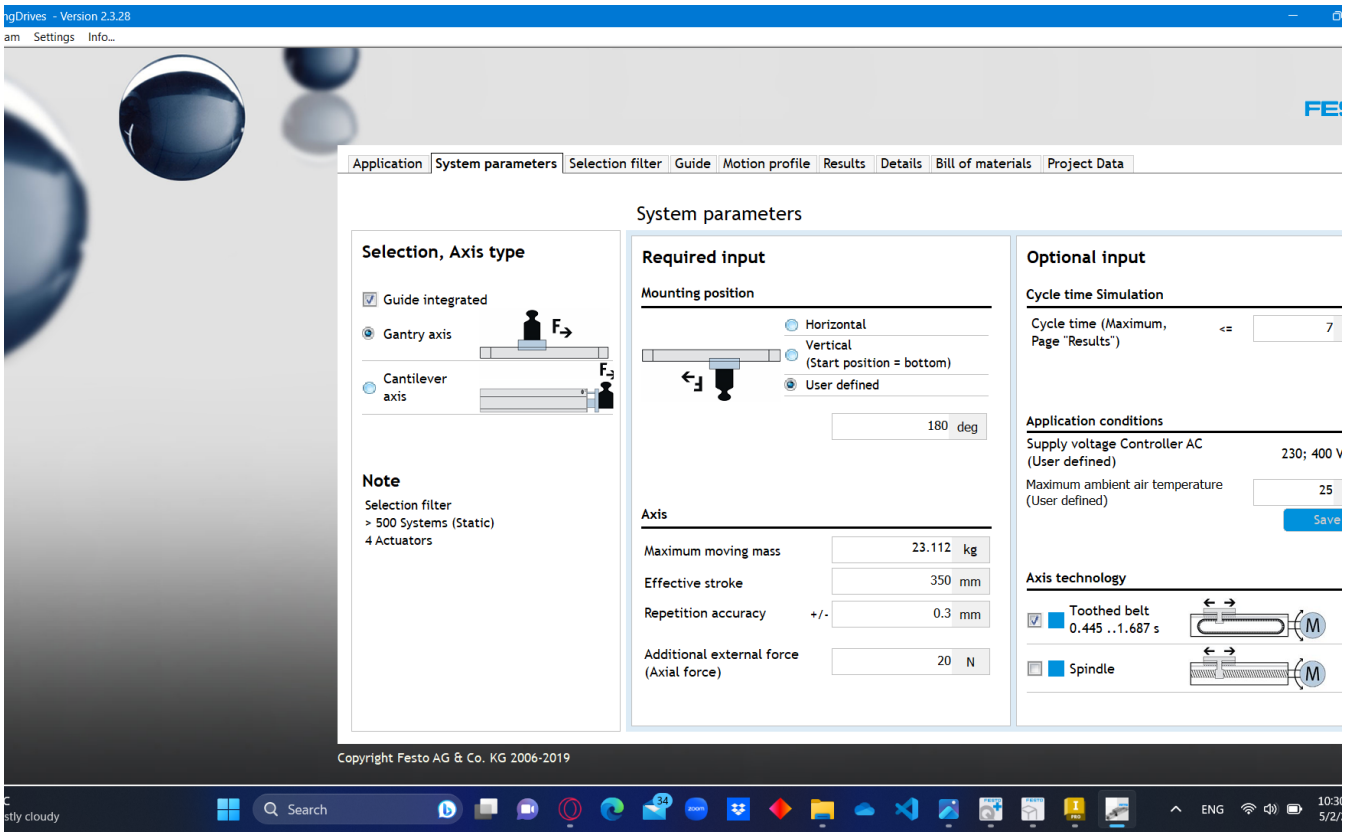
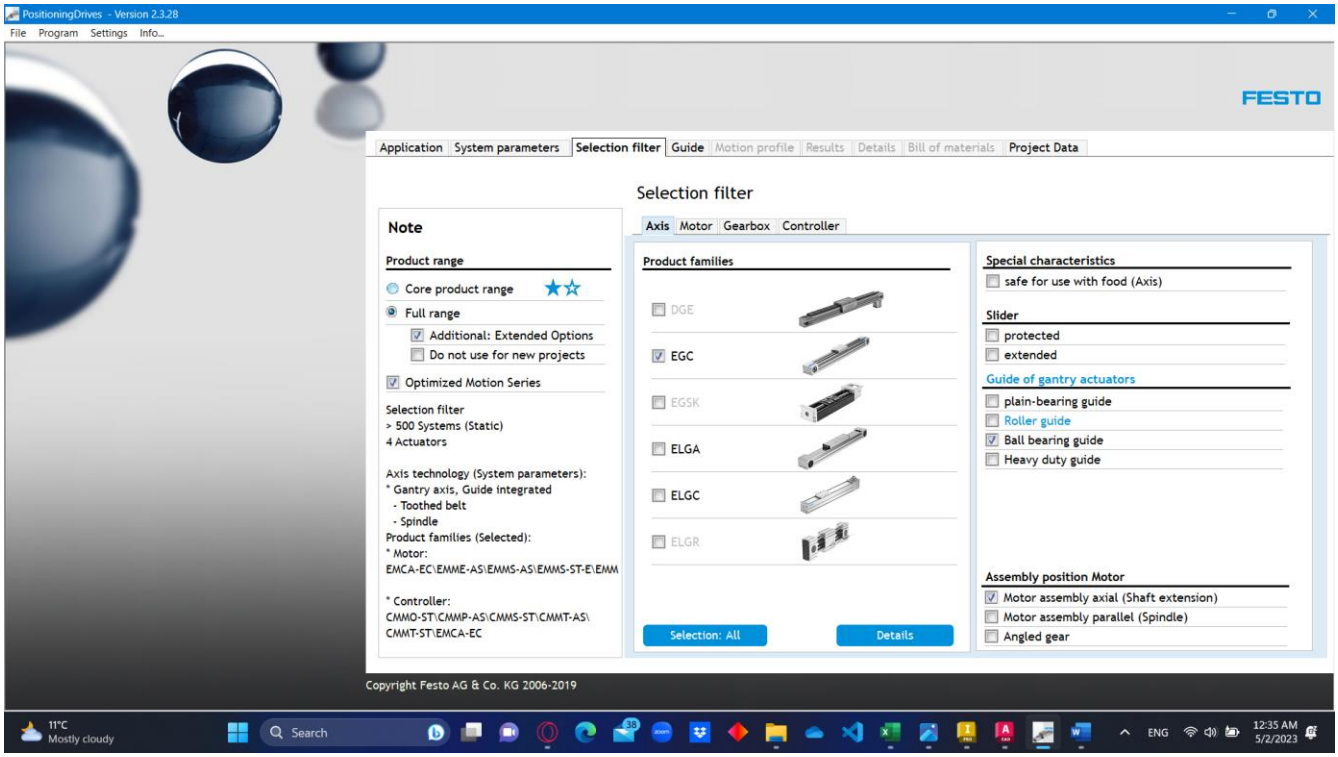
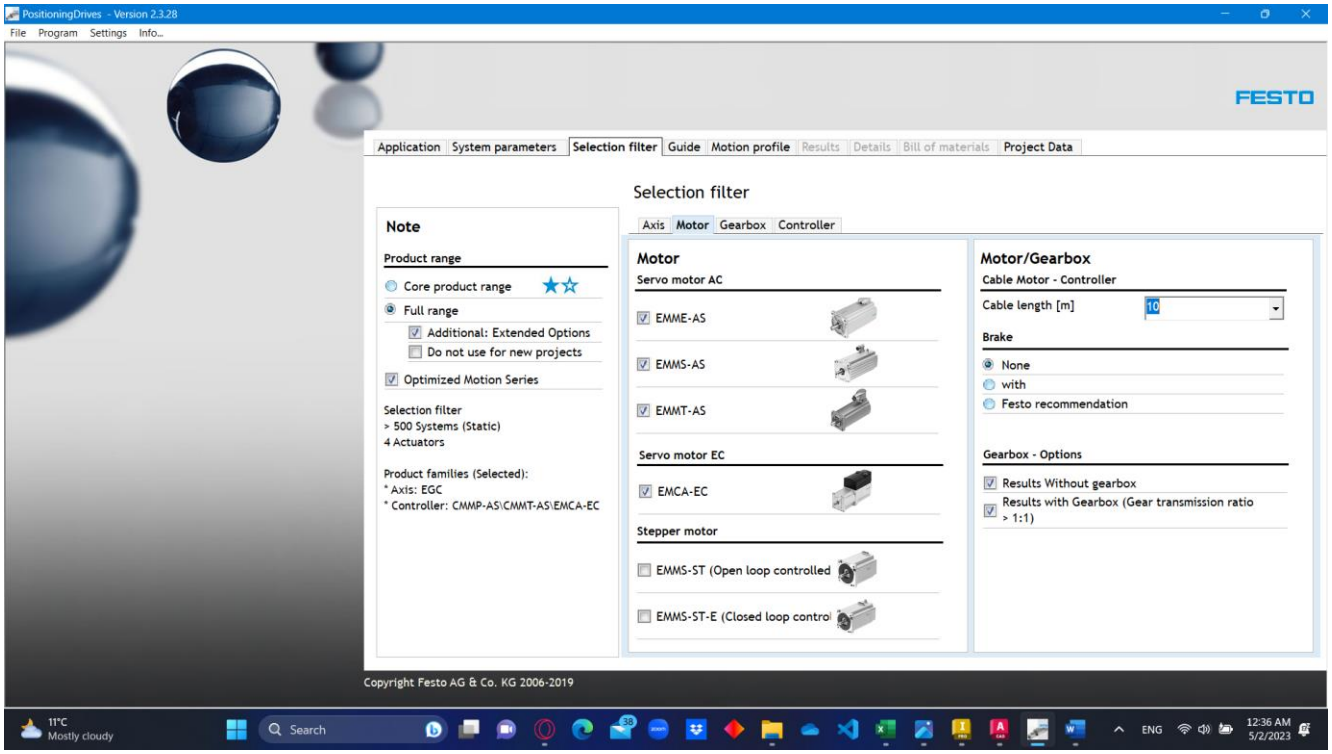

gDrives - Version 2.3.28
am Settings Info...
Application System parameters Selection filter Guide Motion profile Results Details Bill of materials Project Data
System parameters
Selection, Axis type
Guide integrated
Gantry axis
Cantilever axis
Note
Selection filter
> 500 Systems (Static)
4 Actuators
Required input
Mounting position
Horizontal
Vertical
(Start position = bottom)
User defined
180 deg
Axis
Maximum moving mass 23.112 kg
Effective stroke 350 mm
Repetition accuracy +/- 0.3 mm
Additional external force (Axial force) 20 N
Optional input
Cycle time Simulation
Cycle time (Maximum, Page "Results") <= 7
Application conditions
Supply voltage Controller AC (User defined) 230; 400 V
Maximum ambient air temperature (User defined) 25
Save
Axis technology
Toothed belt 0.445 ..1.687 s
Spindle
Copyright Festo AG & Co. KG 2006-2019
Search
ENG


PositioningDrives - Version 2.3.28
File Program Settings Info...
FESTO
Application System parameters Selection filter Guide Motion profile Results Details Bill of materials Project Data
Selection filter
Note
Product range
Core product range
Full range
Additional: Extended Options
Do not use for new projects
Optimized Motion Series
Selection filter
> 500 Systems (Static)
4 Actuators
Axis technology (System parameters):
* Gantry axis, Guide integrated
- Toothed belt
- Spindle
Product families (Selected):
* Motor:
EMCA-EC\EMME-AS\EMMS-AS\EMMS-ST-E\EMM
* Controller:
CMMO-ST\CMMP-AS\CMMS-ST\CMMT-AS\
CMMT-ST\EMCA-EC
Axis Motor Gearbox Controller
Product families
DGE
EGC
EGSK
ELGA
ELGC
ELGR
Selection: All
Details
Special characteristics
safe for use with food (Axis)
Slider
protected
extended
Guide of gantry actuators
plain-bearing guide
Roller guide
Ball bearing guide
Heavy duty guide
Assembly position Motor
Motor assembly axial (Shaft extension)
Motor assembly parallel (Spindle)
Angled gear
Copyright Festo AG & Co. KG 2006-2019
11°C
Mostly cloudy
Search
ENG
12:35 AM
5/2/2023


PositioningDrives - Version 2.3.28
File Program Settings Info...
FESTO
Application System parameters Selection filter Guide Motion profile Results Details Bill of materials Project Data
Selection filter
Note
Product range
Core product range
Full range
Additional: Extended Options
Do not use for new projects
Optimized Motion Series
Selection filter
> 500 Systems (Static)
4 Actuators
Product families (Selected):
* Axis: EGC
* Controller: CMMP-AS\CMMT-AS\EMCA-EC
Axis Motor Gearbox Controller
Motor
Servo motor AC
EMME-AS
EMMS-AS
EMMT-AS
Servo motor EC
EMCA-EC
Stepper motor
EMMS-ST (Open loop controlled
EMMS-ST-E (Closed loop contro
Motor/Gearbox
Cable Motor - Controller
Cable length [m]
10
Brake
None
with
Festo recommendation
Gearbox - Options
Results Without gearbox
Results with Gearbox (Gear transmission ratio > 1:1)
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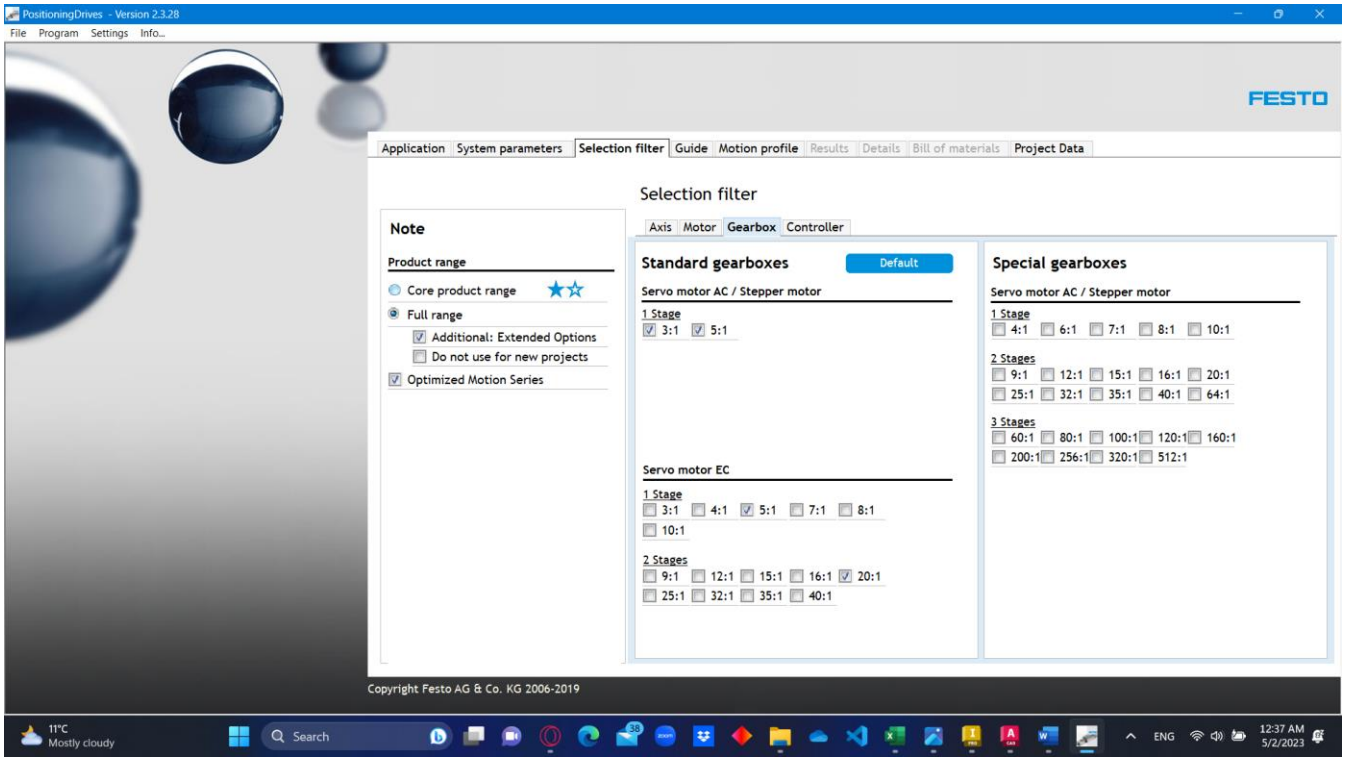
11°C
Mostly cloudy
Search
ENG
12:36 AM
5/2/2023


PositioningDrives - Version 2.3.28
File Program Settings Info...
FESTO
Application System parameters Selection filter Guide Motion profile Results Details Bill of materials Project Data
Selection filter
Note
Product range
Core product range
Full range
Additional: Extended Options
Do not use for new projects
Optimized Motion Series
Axis Motor Gearbox Controller
Standard gearboxes
Default
Servo motor AC / Stepper motor
1 Stage
3:1 5:1
Servo motor EC
1 Stage
3:1 4:1 5:1 7:1 8:1
10:1
2 Stages
9:1 12:1 15:1 16:1 20:1
25:1 32:1 35:1 40:1
Special gearboxes
Servo motor AC / Stepper motor
1 Stage
4:1 6:1 7:1 8:1 10:1
2 Stages
9:1 12:1 15:1 16:1 20:1
25:1 32:1 35:1 40:1 64:1
3 Stages
60:1 80:1 100:1 120:1 160:1
200:1 256:1 320:1 512:1
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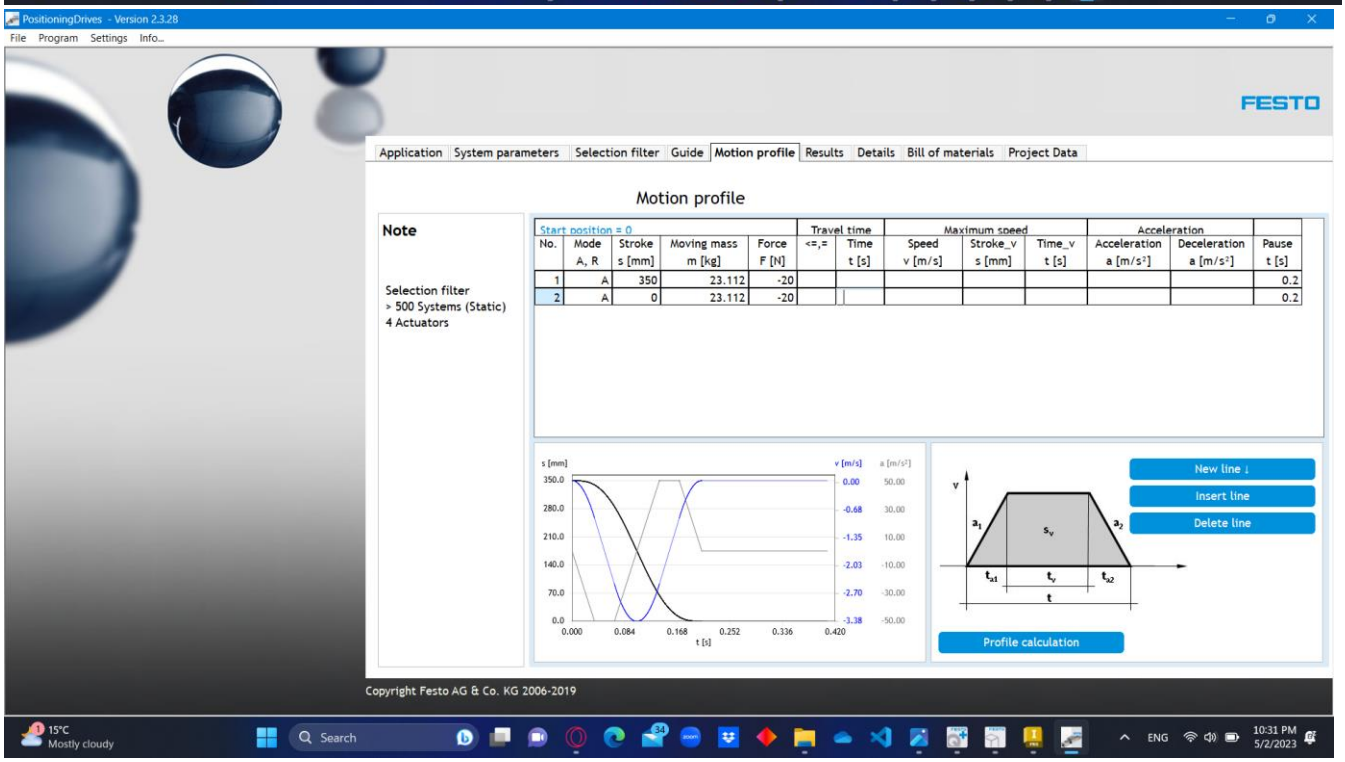
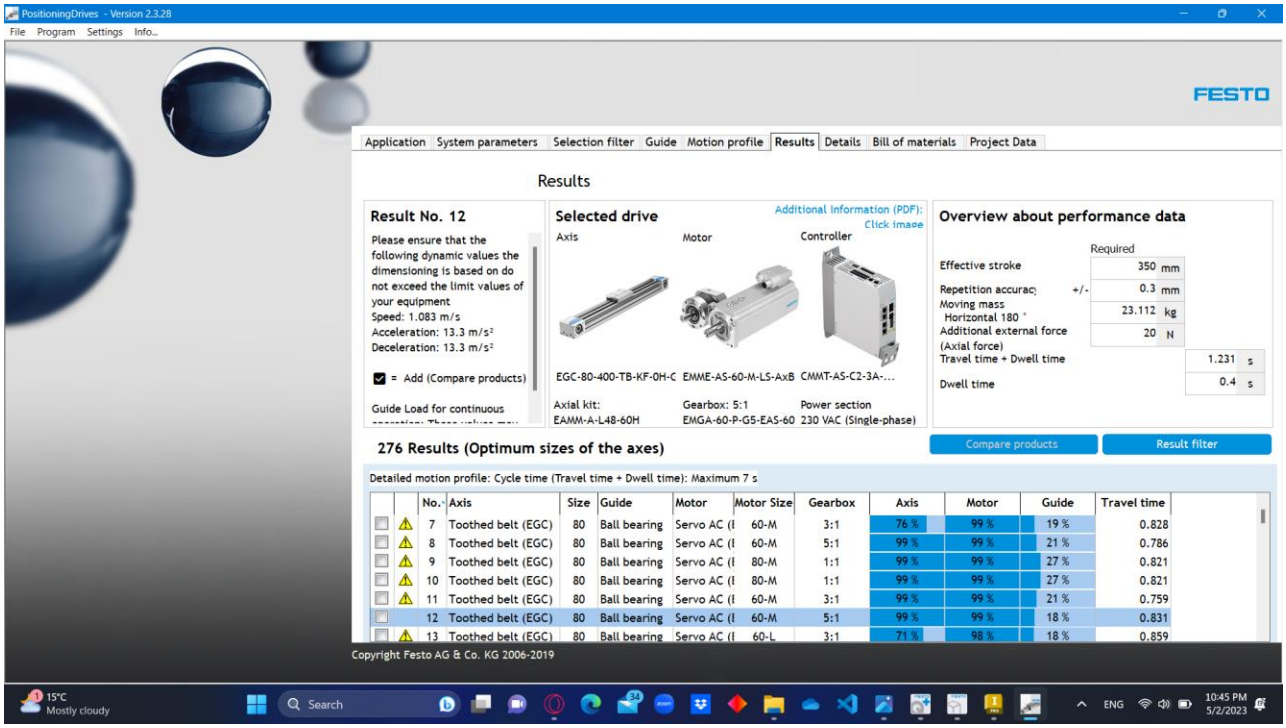
11°C Mostly cloudy
Search
ENG
12:37 AM 5/2/2023


PositioningDrives - Version 2.3.28
File Program Settings Info...
FESTO
Application System parameters Selection filter Guide Motion profile Results Details Bill of materials Project Data
Motion profile
Note
Selection filter
> 500 Systems (Static)
4 Actuators
Start position = 0
Travel time
Maximum speed
Acceleration
No. Mode A, R Stroke s [mm] Moving mass m [kg] Force F [N] <=,= Time t [s] Speed v [m/s] Stroke_v s [mm] Time_v t [s] Acceleration a [m/s²] Deceleration a [m/s²] Pause t [s]
1 A 350 23.112 -20 0.2
2 A 0 23.112 -20 0.2
New line ↓
Insert line
Delete line
Profile calculation
Copyright Festo AG & Co. KG 2006-2019
15°C Mostly cloudy
Search
ENG
10:31 PM 5/2/2023


PositioningDrives - Version 2.3.28
File Program Settings Info...
FESTO
Application System parameters Selection filter Guide Motion profile Results Details Bill of materials Project Data
Results
Result No. 12
Please ensure that the following dynamic values the dimensioning is based on do not exceed the limit values of your equipment
Speed: 1.083 m/s
Acceleration: 13.3 m/s²
Deceleration: 13.3 m/s²
= Add (Compare products)
Guide Load for continuous
Selected drive
Additional information (PDF): Click image
Axis
Motor
Controller
EGC-80-400-TB-KF-0H-C
EMME-AS-60-M-LS-AxB
CMMT-AS-C2-3A-...
Axial kit: EAMM-A-L48-60H
Gearbox: 5:1 EMGA-60-P-G5-EAS-60
Power section 230 VAC (Single-phase)
Overview about performance data
Required
Effective stroke 350 mm
Repetition accuracy +/- 0.3 mm
Moving mass Horizontal 180 ° 23.112 kg
Additional external force (Axial force) 20 N
Travel time + Dwell time 1.231 s
Dwell time 0.4 s
276 Results (Optimum sizes of the axes)
Compare products
Result filter
Detailed motion profile: Cycle time (Travel time + Dwell time): Maximum 7 s
No. Axis Size Guide Motor Motor Size Gearbox Axis Motor Guide Travel time
7 Toothed belt (EGC) 80 Ball bearing Servo AC (I 60-M 3:1 76 % 99 % 19 % 0.828
8 Toothed belt (EGC) 80 Ball bearing Servo AC (I 60-M 5:1 99 % 99 % 21 % 0.786
9 Toothed belt (EGC) 80 Ball bearing Servo AC (I 80-M 1:1 99 % 99 % 27 % 0.821
10 Toothed belt (EGC) 80 Ball bearing Servo AC (I 80-M 1:1 99 % 99 % 27 % 0.821
11 Toothed belt (EGC) 80 Ball bearing Servo AC (I 60-M 3:1 99 % 99 % 21 % 0.759
12 Toothed belt (EGC) 80 Ball bearing Servo AC (I 60-M 5:1 99 % 99 % 18 % 0.831
13 Toothed belt (EGC) 80 Ball bearing Servo AC (I 60-L 3:1 71 % 98 % 18 % 0.859
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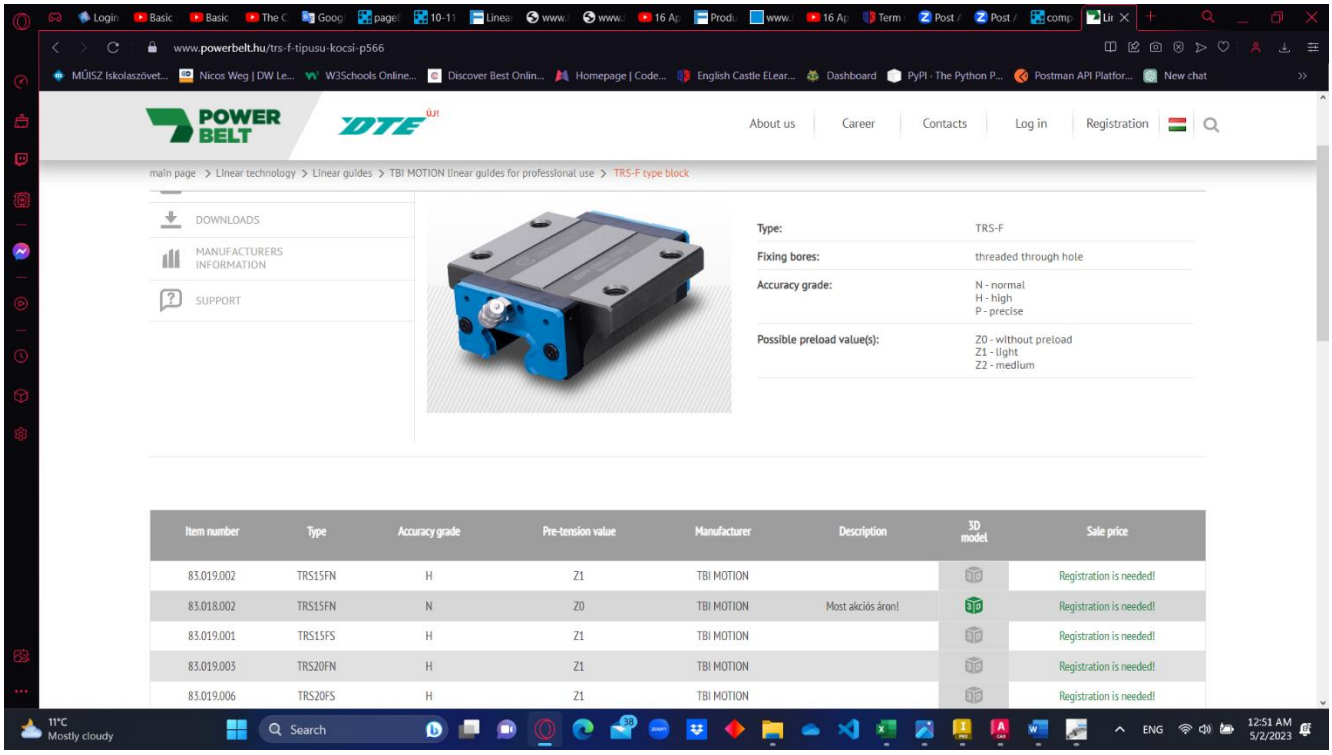
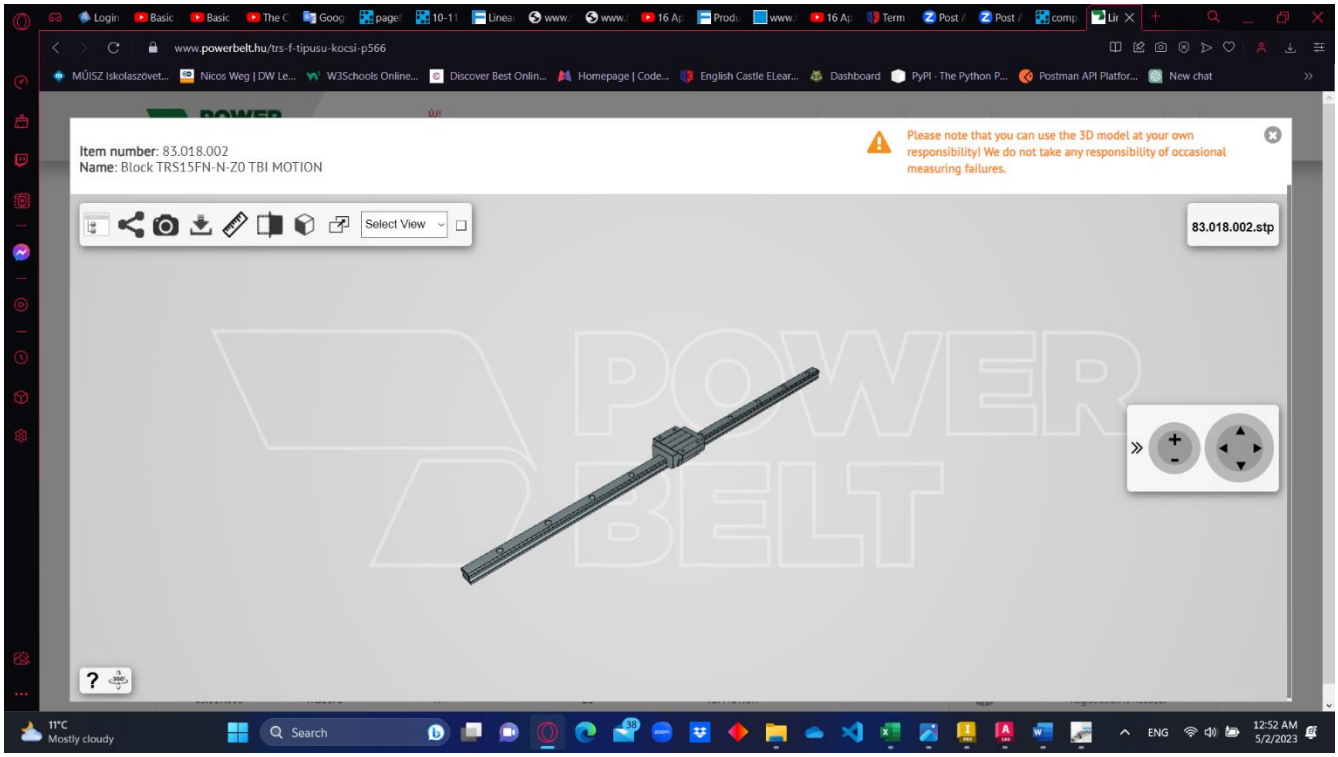
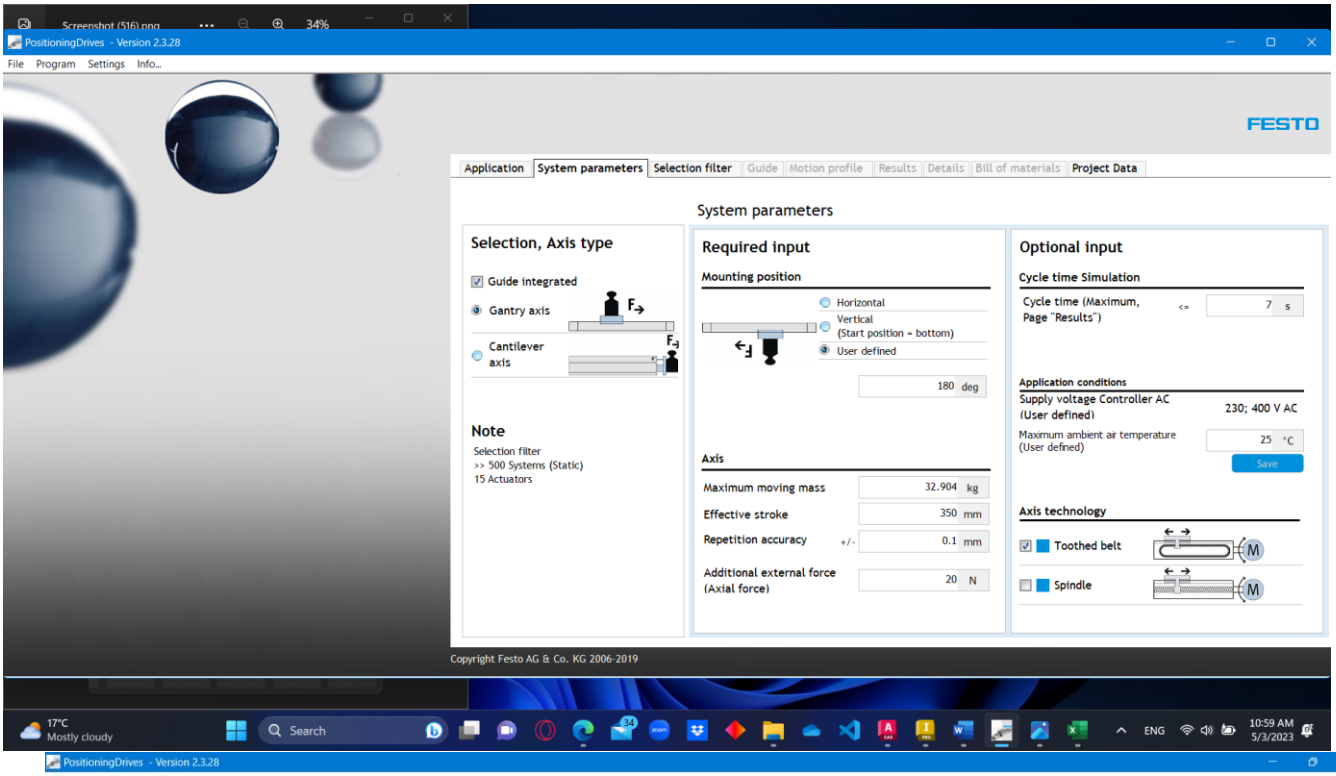
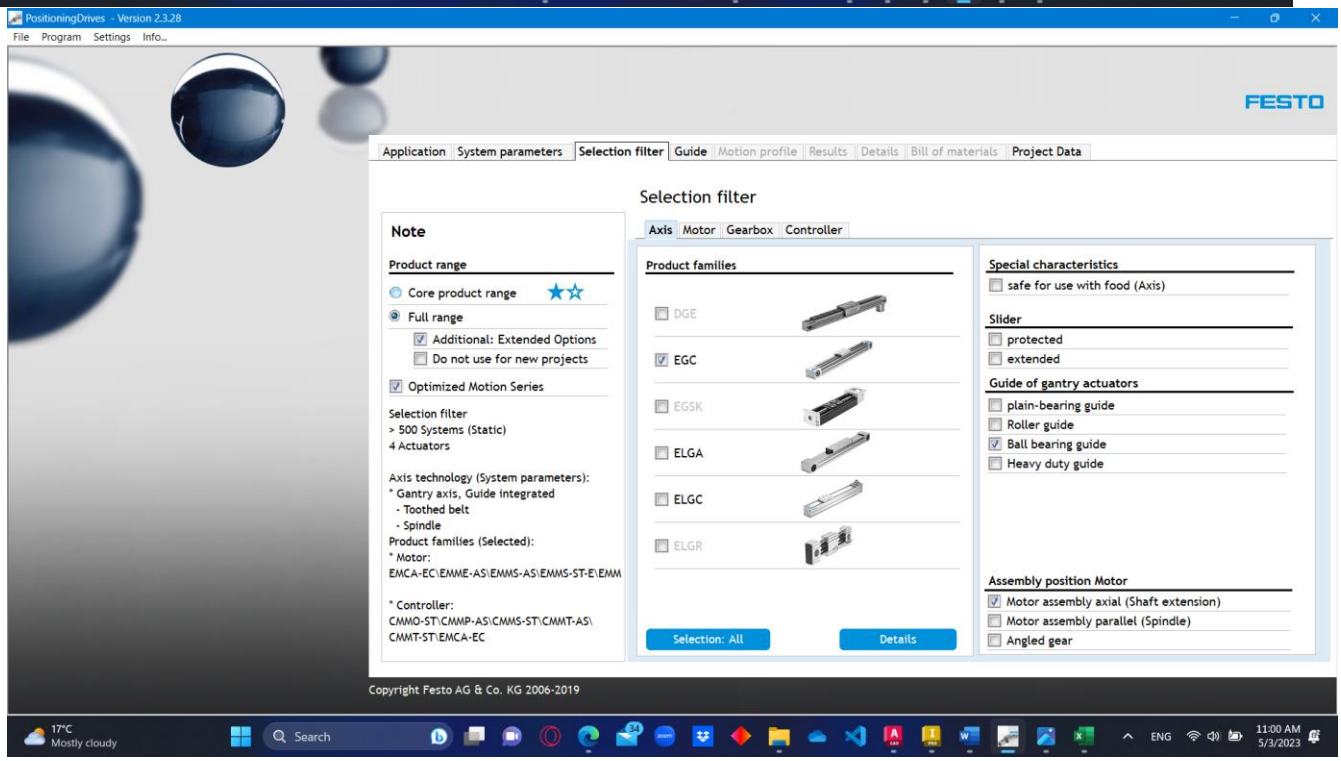
15°C Mostly cloudy
Search
ENG
10:45 PM 5/2/2023

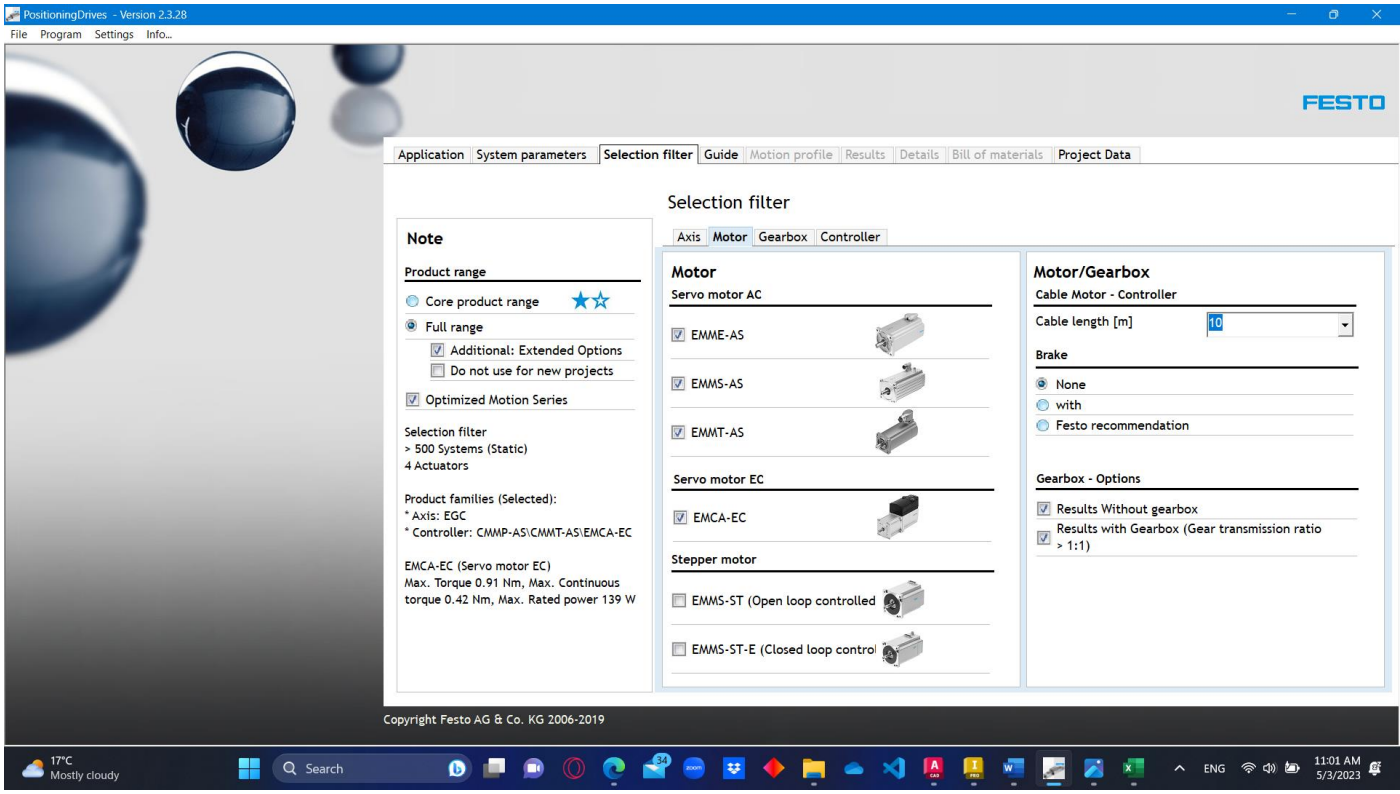

www.powerbelt.hu/trs-f-tipusu-kocsi-p566
POWER BELT
About us Career Contacts Log in Registration
main page > Linear technology > Linear guides > TBI MOTION linear guides for professional use > TRS-F type block
DOWNLOADS
MANUFACTURERS INFORMATION
SUPPORT
Type: TRS-F
Fixing bores: threaded through hole
Accuracy grade: N - normal H - high P - precise
Possible preload value(s): Z0 - without preload Z1 - light Z2 - medium
Item number Type Accuracy grade Pre-tension value Manufacturer Description 3D model Sale price
83.019.002 TRS15FN H Z1 TBI MOTION Registration is needed!
83.018.002 TRS15FN N Z0 TBI MOTION Most akciós áron! Registration is needed!
83.019.001 TRS15FS H Z1 TBI MOTION Registration is needed!
83.019.003 TRS20FN H Z1 TBI MOTION Registration is needed!
83.019.006 TRS20FS H Z1 TBI MOTION Registration is needed!
11°C Mostly cloudy
Search
ENG
12:51 AM 5/2/2023

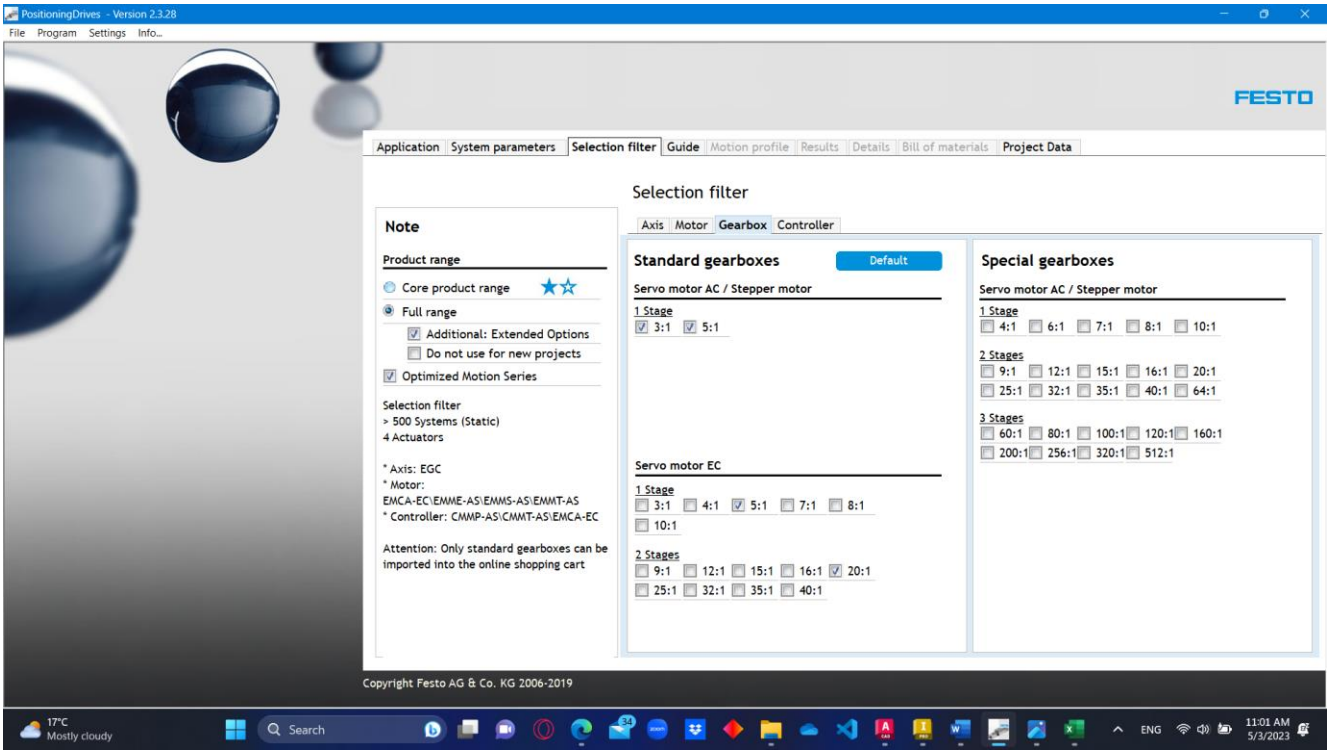

www.powerbelt.hu/trs-f-tipusu-kocsi-p566
Item number: 83.018.002
Name: Block TRS15FN-N-Z0 TBI MOTION
Please note that you can use the 3D model at your own responsibility! We do not take any responsibility of occasional measuring failures.
Select View
83.018.002.stp
POWER BELT
11°C
Mostly cloudy
Search
ENG
12:52 AM
5/2/2023

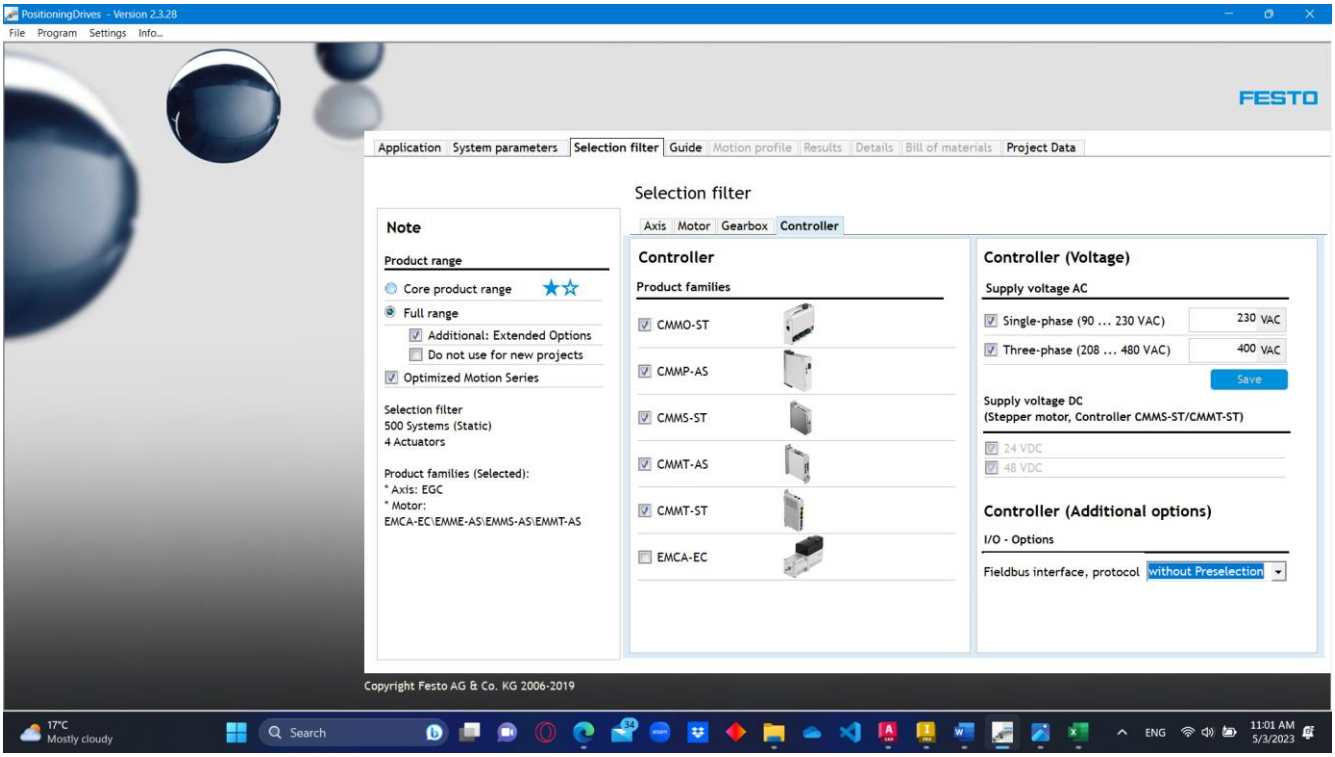
III. For X-axis

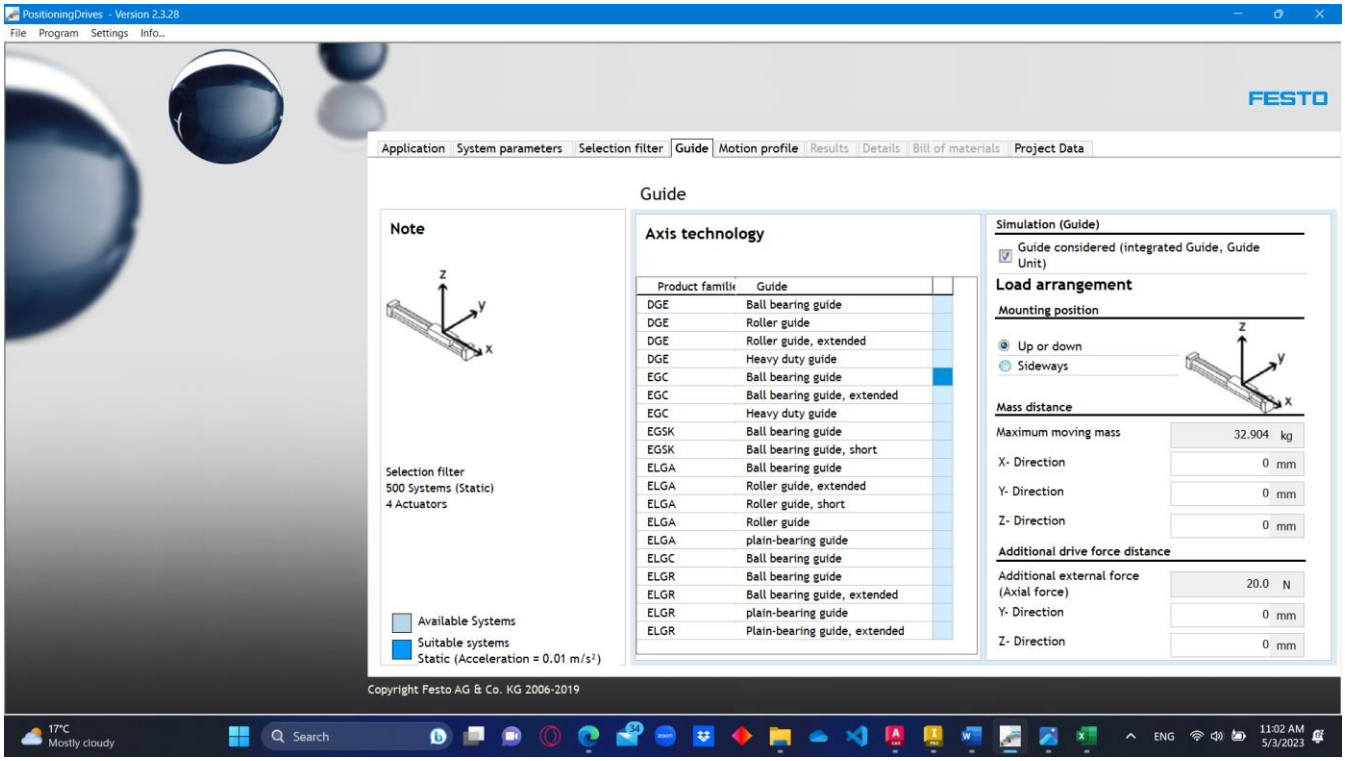


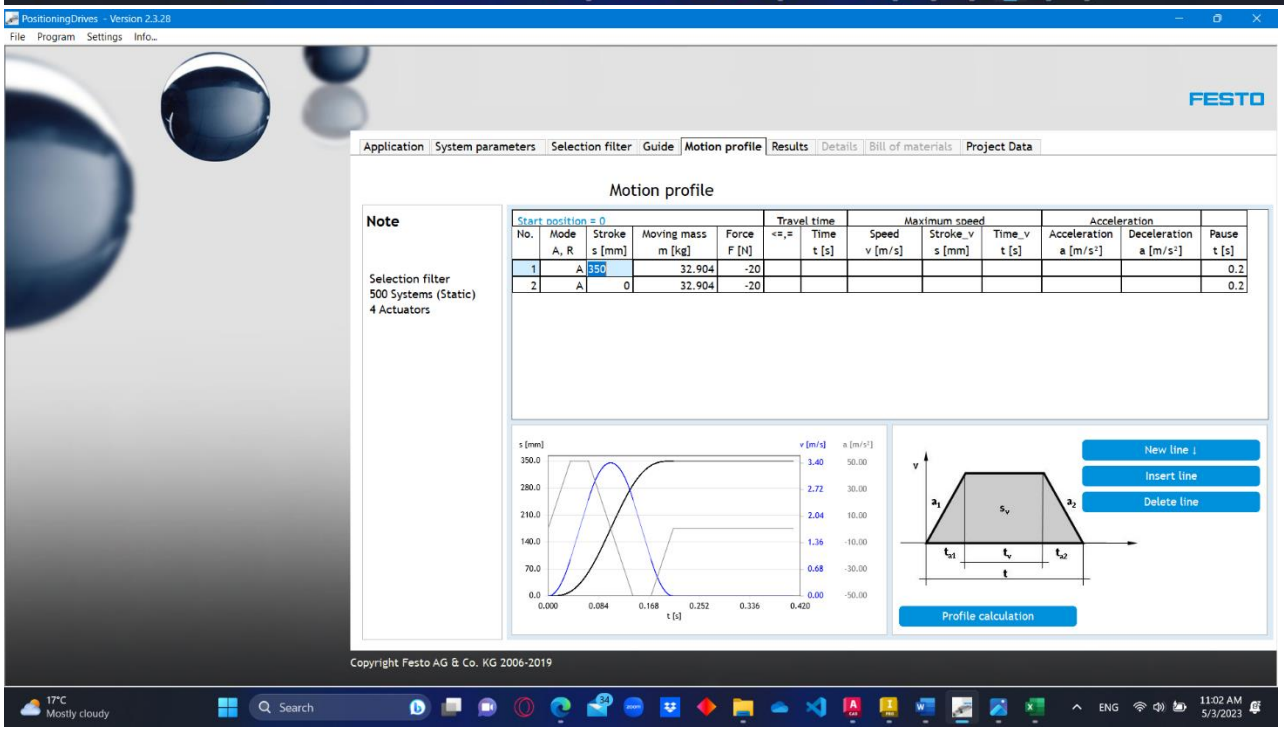


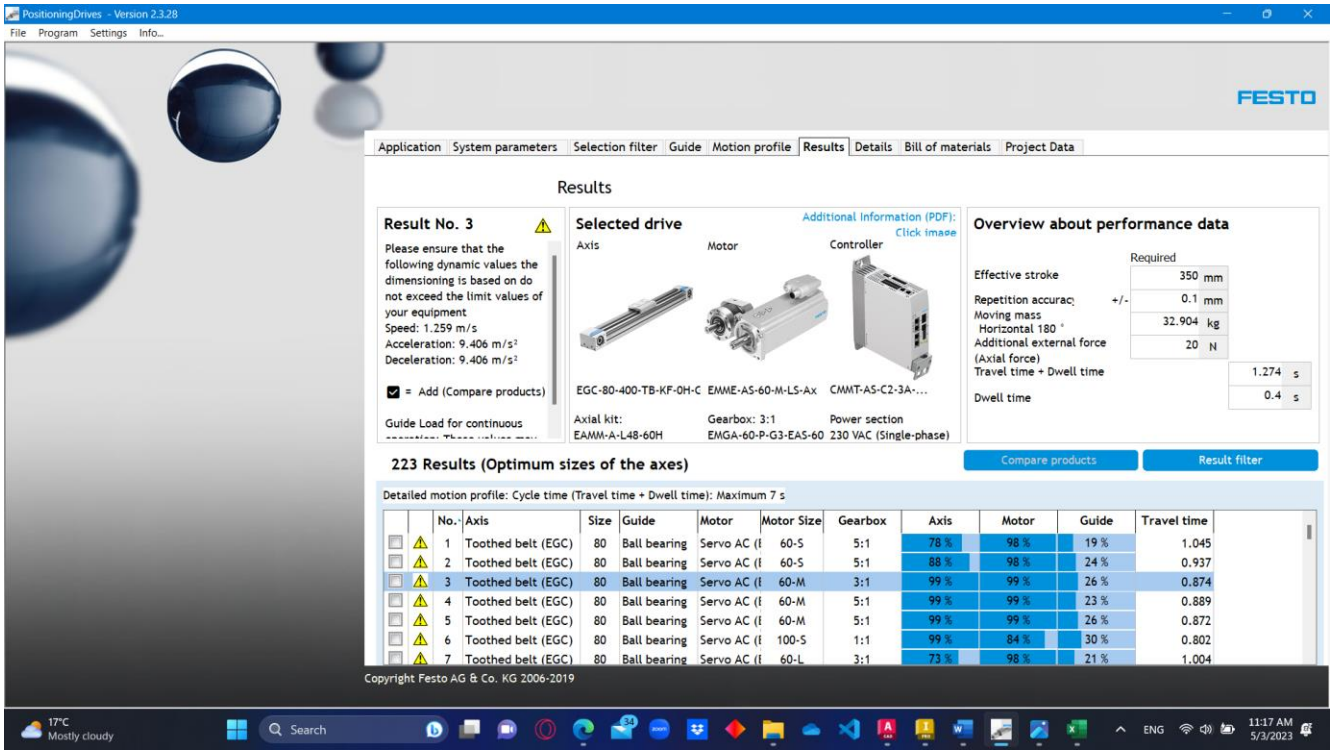

PositioningDrives - Version 2.3.28
File Program Settings Info...
FESTO
Application System parameters Selection filter Guide Motion profile Results Details Bill of materials Project Data
Selection filter
Note
Product range
Core product range
Full range
Additional: Extended Options
Do not use for new projects
Optimized Motion Series
Selection filter
> 500 Systems (Static)
4 Actuators
Product families (Selected):
* Axis: EGC
* Controller: CMMP-AS\CMMT-AS\EMCA-EC
EMCA-EC (Servo motor EC)
Max. Torque 0.91 Nm, Max. Continuous torque 0.42 Nm, Max. Rated power 139 W
Axis Motor Gearbox Controller
Motor
Servo motor AC
EMME-AS
EMMS-AS
EMMT-AS
Servo motor EC
EMCA-EC
Stepper motor
EMMS-ST (Open loop controlled
EMMS-ST-E (Closed loop contro
Motor/Gearbox
Cable Motor - Controller
Cable length [m] 10
Brake
None
with
Festo recommendation
Gearbox - Options
Results Without gearbox
Results with Gearbox (Gear transmission ratio > 1:1)
Copyright Festo AG & Co. KG 2006-2019
17°C
Mostly cloudy
Search
ENG
11:01 AM
5/3/2023


PositioningDrives - Version 2.3.28
File Program Settings Info...
FESTO
Application System parameters Selection filter Guide Motion profile Results Details Bill of materials Project Data
Selection filter
Note
Product range
Core product range
Full range
Additional: Extended Options
Do not use for new projects
Optimized Motion Series
Selection filter
> 500 Systems (Static)
4 Actuators
* Axis: EGC
* Motor:
EMCA-EC\EMME-AS\EMMS-AS\EMMT-AS
* Controller: CMMP-AS\CMMT-AS\EMCA-EC
Attention: Only standard gearboxes can be imported into the online shopping cart
Axis Motor Gearbox Controller
Standard gearboxes
Default
Servo motor AC / Stepper motor
1 Stage
3:1 5:1
Servo motor EC
1 Stage
3:1 4:1 5:1 7:1 8:1
10:1
2 Stages
9:1 12:1 15:1 16:1 20:1
25:1 32:1 35:1 40:1
Special gearboxes
Servo motor AC / Stepper motor
1 Stage
4:1 6:1 7:1 8:1 10:1
2 Stages
9:1 12:1 15:1 16:1 20:1
25:1 32:1 35:1 40:1 64:1
3 Stages
60:1 80:1 100:1 120:1 160:1
200:1 256:1 320:1 512:1
Copyright Festo AG & Co. KG 2006-2019
17°C
Mostly cloudy
Search
ENG
11:01 AM
5/3/2023


PositioningDrives - Version 2.3.28
File Program Settings Info...
FESTO
Application System parameters Selection filter Guide Motion profile Results Details Bill of materials Project Data
Selection filter
Note
Product range
Core product range
Full range
Additional: Extended Options
Do not use for new projects
Optimized Motion Series
Selection filter
500 Systems (Static)
4 Actuators
Product families (Selected):
* Axis: EGC
* Motor:
EMCA-EC\EMME-AS\EMMS-AS\EMMT-AS
Axis Motor Gearbox Controller
Controller
Product families
CMMO-ST
CMMP-AS
CMMS-ST
CMMT-AS
CMMT-ST
EMCA-EC
Controller (Voltage)
Supply voltage AC
Single-phase (90 ... 230 VAC) 230 VAC
Three-phase (208 ... 480 VAC) 400 VAC
Save
Supply voltage DC
(Stepper motor, Controller CMMS-ST/CMMT-ST)
24 VDC
48 VDC
Controller (Additional options)
I/O - Options
Fieldbus interface, protocol without Preselection
Copyright Festo AG & Co. KG 2006-2019
17°C
Mostly cloudy
Search
ENG
11:01 AM
5/3/2023


PositioningDrives - Version 2.3.28
File Program Settings Info...
FESTO
Application System parameters Selection filter Guide Motion profile Results Details Bill of materials Project Data
Guide
Note
Selection filter
500 Systems (Static)
4 Actuators
Available Systems
Suitable systems
Static (Acceleration = 0.01 m/s²)
Axis technology
Product family Guide
DGE Ball bearing guide
DGE Roller guide
DGE Roller guide, extended
DGE Heavy duty guide
EGC Ball bearing guide
EGC Ball bearing guide, extended
EGC Heavy duty guide
EGSK Ball bearing guide
EGSK Ball bearing guide, short
ELGA Ball bearing guide
ELGA Roller guide, extended
ELGA Roller guide, short
ELGA Roller guide
ELGA plain-bearing guide
ELGC Ball bearing guide
ELGR Ball bearing guide
ELGR Ball bearing guide, extended
ELGR plain-bearing guide
ELGR Plain-bearing guide, extended
Simulation (Guide)
Guide considered (integrated Guide, Guide Unit)
Load arrangement
Mounting position
Up or down
Sideways
Mass distance
Maximum moving mass 32.904 kg
X- Direction 0 mm
Y- Direction 0 mm
Z- Direction 0 mm
Additional drive force distance
Additional external force (Axial force) 20.0 N
Y- Direction 0 mm
Z- Direction 0 mm
Copyright Festo AG & Co. KG 2006-2019
17°C Mostly cloudy
Search
ENG
11:02 AM 5/3/2023


PositioningDrives - Version 2.3.28
File Program Settings Info...
FESTO
Application System parameters Selection filter Guide Motion profile Results Details Bill of materials Project Data
Motion profile
Note
Selection filter
500 Systems (Static)
4 Actuators
Start position = 0
Travel time
Maximum speed
Acceleration
No. Mode A, R Stroke s [mm] Moving mass m [kg] Force F [N] <=,= Time t [s] Speed v [m/s] Stroke_v s [mm] Time_v t [s] Acceleration a [m/s²] Deceleration a [m/s²] Pause t [s]
1 A 350 32.904 -20 0.2
2 A 0 32.904 -20 0.2
s [mm]
v [m/s]
a [m/s²]
t [s]
New line ↓
Insert line
Delete line
Profile calculation
Copyright Festo AG & Co. KG 2006-2019
17°C Mostly cloudy
Search
ENG
11:02 AM 5/3/2023



5. Calculation of the dynamic forces and torques! You can use „Matlab-simulink”, or “Matlab-simscape” software. Check all joints in the mechanism (sliders) for loads act on it! If it is needed, you can use additional links and joints to help to carry the forces and torques! The task may be calculated with scientific calculator or with “Matlab-simulink”, or Matlab-simscape”, and must be written in the documentation.

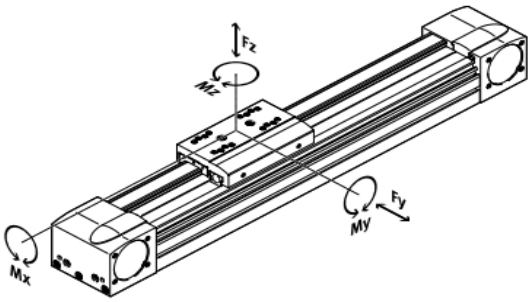
I. X-axis: (EGC-80-350-TB-KF)

Toothed belt axes EGC-TB-KF, with recirculating ball bearing guide

Data sheet

Characteristic load values

The indicated forces and torques refer to the slide surface. The point of application of force is the point where the centre of the guide and the longitudinal centre of the slide intersect. These values must not be exceeded during dynamic operation. Special attention must be paid to the deceleration phase.



Max. permissible forces and torques for a service life of 5000 km

Size		50	70	80	120	185
$Fy_{max.}$	[N]	650	1850	3050	6890	15200
$Fz_{max.}$	[N]	650	1850	3050	6890	15200
$Mx_{max.}$	[Nm]	3.5	16	36	144	529
$My_{max.}/Mz_{max.}$						
EGC-...-GK/-GP	[Nm]	10	51	97	380	1157
$My_{max.}/Mz_{max.}$						
EGC-...-GV/-GQ	[Nm]	–	132	228	680	1820

Note

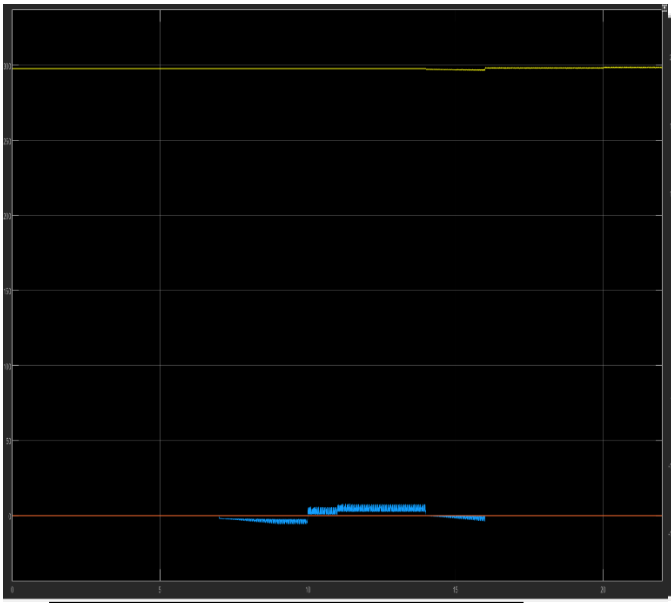
For a guide system to have a service life of 5000 km, the load comparison factor must have a value of fv ≤ 1, based on the maximum permissible forces and torques for a service life of 5000 km.

If the axis is subjected to two or more of the indicated forces and torques simultaneously, the following equation must be satisfied in addition to the indicated maximum loads:

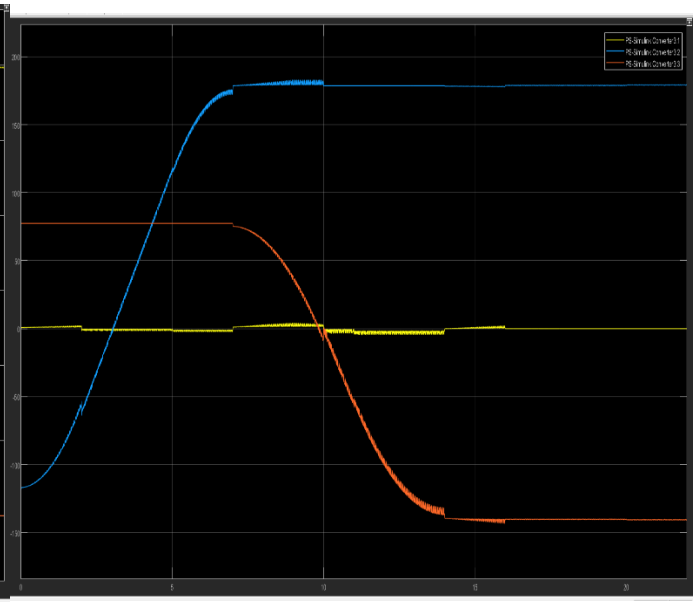
Calculating the load comparison factor:

$$f_v = \frac{|F_{y1}|}{F_{y2}} + \frac{|F_{z1}|}{F_{z2}} + \frac{|M_{x1}|}{M_{x2}} + \frac{|M_{y1}|}{M_{y2}} + \frac{|M_{z1}|}{M_{z2}} \leq 1$$

F_1/M_1 = dynamic value
F_2/M_2 = maximum value



Constrain Force



Constrain Torque

The Maximum Torque is 36[Nm] while in the simulation is 50[Nm] and to solve this issue I used two supporting guides.

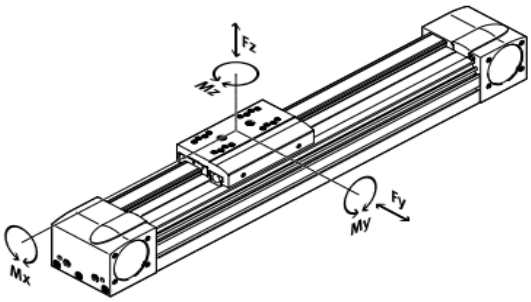
II. Y-axis: (EGC-80-300-TB-KF)

Toothed belt axes EGC-TB-KF, with recirculating ball bearing guide

Data sheet

Characteristic load values

The indicated forces and torques refer to the slide surface. The point of application of force is the point where the centre of the guide and the longitudinal centre of the slide intersect. These values must not be exceeded during dynamic operation. Special attention must be paid to the deceleration phase.



Max. permissible forces and torques for a service life of 5000 km

Size		50	70	80	120	185
$Fy_{max.}$	[N]	650	1850	3050	6890	15200
$Fz_{max.}$	[N]	650	1850	3050	6890	15200
$Mx_{max.}$	[Nm]	3.5	16	36	144	529
$My_{max.}/Mz_{max.}$						
EGC-...-GK/-GP	[Nm]	10	51	97	380	1157
$My_{max.}/Mz_{max.}$						
EGC-...-GV/-GQ	[Nm]	–	132	228	680	1820

Note

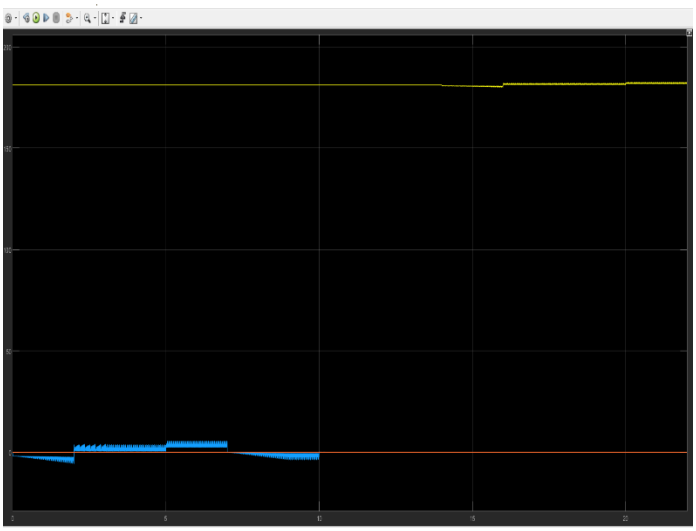
For a guide system to have a service life of 5000 km, the load comparison factor must have a value of fv ≤ 1, based on the maximum permissible forces and torques for a service life of 5000 km.

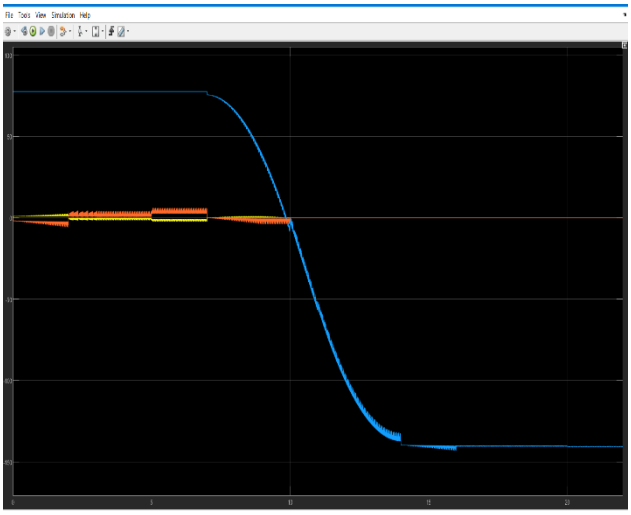
If the axis is subjected to two or more of the indicated forces and torques simultaneously, the following equation must be satisfied in addition to the indicated maximum loads:

Calculating the load comparison factor:

$$f_v = \frac{|F_{y1}|}{F_{y2}} + \frac{|F_{z1}|}{F_{z2}} + \frac{|M_{x1}|}{M_{x2}} + \frac{|M_{y1}|}{M_{y2}} + \frac{|M_{z1}|}{M_{z2}} \leq 1$$

F_1/M_1 = dynamic value
F_2/M_2 = maximum value





Constrain Force

Constrain Torque

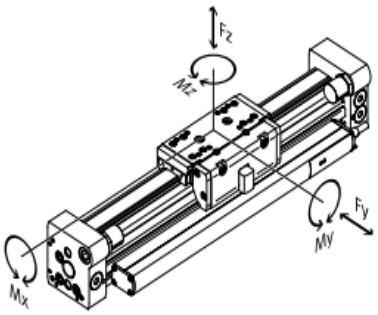
III. Z-axis: (DGCI-25-225-KF-PPV-A)

Linear drives DGCI, with displacement encoder

Data sheet

Characteristic load values for linear drive with recirculating ball bearing guide and guide

The indicated forces and torques refer to the slide surface and the centre of the slide.
These values must not be exceeded during dynamic operation. Special attention must be paid to the deceleration phase.



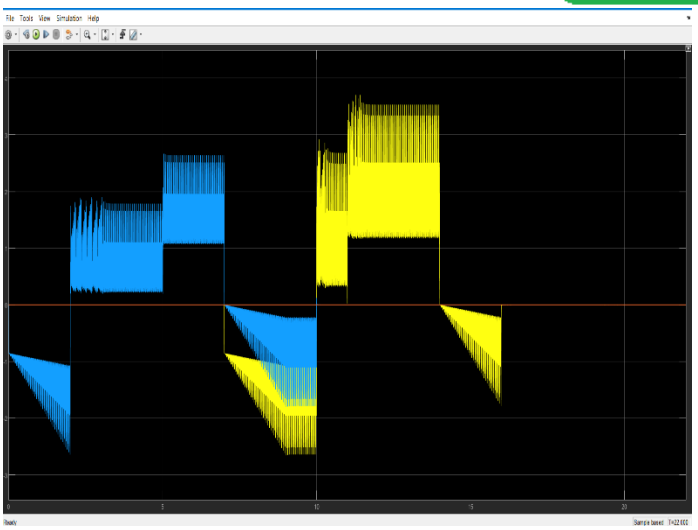
If the drive is subjected to two or more of the indicated forces and torques simultaneously, the following equation must be satisfied in addition to the indicated maximum loads:

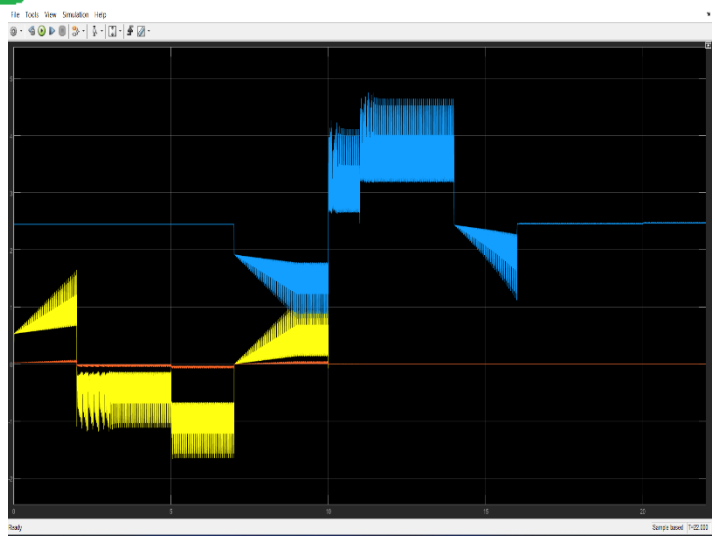
$$f_v = \frac{|F_{y1}|}{F_{y2}} + \frac{|F_{z1}|}{F_{z2}} + \frac{|M_{x1}|}{M_{x2}} + \frac{|M_{y1}|}{M_{y2}} + \frac{|M_{z1}|}{M_{z2}} \leq 1$$

F1/M1 = dynamic value
F2/M2 = maximum value

Permissible forces and torques

Piston Ø		18	25	32	40	63
$Fy_{max.}$	[N]	1850	3050	3310	6890	15200
$Fz_{max.}$	[N]	1850	3050	3310	6890	15200
$Mx_{max.}$	[Nm]	16	36	54	144	529
$My_{max.}$	[Nm]	51	97	150	380	1157
$Mz_{max.}$	[Nm]	51	97	150	380	1157





Constrain Force

Constrain Torque

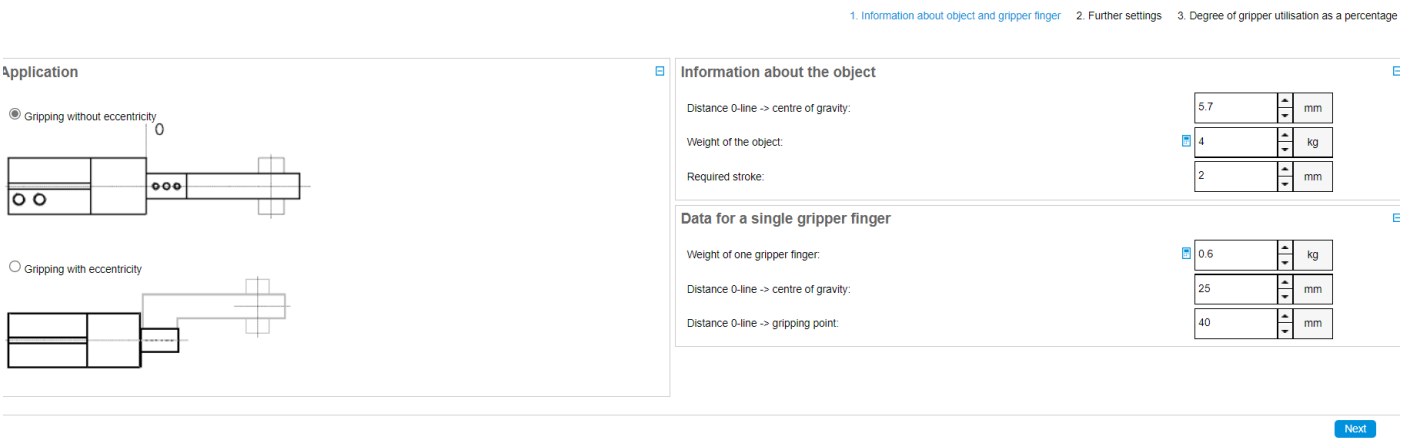
6. part-list with the applied equipment.

Axis	No.	Part Name	Part code	Quantity	Datasheet
Z-axis	544426	servo-pneumatic linear drive	544426_DGCI_25_300_KF_1H_PN_ZUB_F____0_	1	DGCI_EN.PDF (festo.com)
	550170	Proportional directional control valve	550171_VPWP_6_L_5_Q8_10_E_F	1	VPWP_EN.PDF (festo.com)
	548932	axis controller	CPX-CMAX-C1-1	1	CPX-CMAX_EN.PDF (festo.com)
	1254052	Gripper	DHPS-35-A	1	*DHPS_EN.PDF (festo.com)
	177770	Gripper combinations with adapter kit	HMSV-30	1	*DHPS_EN.PDF (festo.com)
	577295	Valve terminal	VSNC_FC_M52_MD_G14_F8_1B2	1	
	551457	Plastic tubing	PEN-6X1-BL	2	OD-TUBING_EN.PDF (festo.com)
	541334	Connecting cable	NEBU-M8G3-K-5-LE3	1	NEBU_EN.PDF (festo.com)
	540349	Shock absorber	YSRW-DGC-25-KF	1	*DGCI_EN.PDF (festo.com)
	186117	Push-in-L-fitting	QSL-G1/8-6	2	QS_EN.PDF (festo.com)
Y-axis	556814	Toothed belt axis-Linear drive	575832_EGC_80_400_TB_KF_0H_GK____0_	1	EGC-TB_EN.PDF (festo.com)
	2042616	Axial kit	1456611_EAMM_A_L48_60H	1	EAMM-A_EN.PDF (festo.com)
	2093136	Servo motor AC	2089701_EMME_AS_60_S_LS_AMB	1	EMME-AS_EN.PDF (festo.com)
	5340816	Controller	CMMT-AS-C2-11A-P3-PN-S1	1	CMMT-AS_EN.PDF (festo.com)

	5118001	Assortment of plugs	NEKM-C6-C45-P3-D	1	CMMT-AS_EN.PDF (festo.com)
	5391547	Motor cable	NEBM-M16G8-E-7.5-Q9-LE8-1	1	*EMME-AS_EN.PDF (festo.com)
	5212314	Encoder cable	NEBM-M12G8-E-7.5-N-R3G8	1	EMME-AS_EN.PDF (festo.com)
	8070984	Operator unit	CDSB-A1	1	CDSB-A1_EN.PDF (festo.com)
	150492	SIES sensor	SIES_Q40B_PA_x_2L	1	
X-axis	556814	Linear drive	575832_EGC_80_400_TB_KF_0H_GK___0_	1	EGC-TB_EN.PDF (festo.com)
	557984	Axial kit	1456611_EAMM_A_L48_60H	1	
	2103467	Servo motor AC	2089731_EMME_AS_60_M_LS_AM	1	
	5340818	Controller	CMMT-AS-C5-11A-P3-PN-S1	1	CMMT-AS_EN.PDF (festo.com)
	5118001	Assortment of plugs	NEKM-C6-C45-P3-D	1	CMMT-AS_EN.PDF (festo.com)
	150492	SIES sensor	SIES_Q40B_PA_x_2L	1	
	8082383	Connecting cable	NEBC-R3G8-KS-0.2-N-S-R3G8-ET	1	CMMT-AS_EN.PDF (festo.com)
	8070984	Operator unit	CDSB-A1	1	CDSB-A1_EN.PDF (festo.com)
	5391547	Motor cable	NEBM-M16G8-E-7.5-Q9-LE8-1	1	*EMME-AS_EN.PDF (festo.com)

Additional components	83.009.007	Linear guide	TRS25VS	4	Linear technology - Linear guides - TBI MOTION linear guides for professional use - TRS-V type block with 2 holes - Power Belt
					Autodesk Inventor Library
	-	Screws	ISO-4017-(M4, M5, M6, M8, M18) DIN-912-M5	70	
	-	Washers	DIN EN ISO 7092-(M4, M5, M6, M8, M9, M20)	140	
	-	Nuts	ISO-4034-(M5, M6, M8, M18) DIN-985-M5	70	

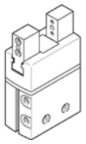
7. Placing a gripper to the end of the kinematic chain!



Standard gripper | Robust gripper | Long stroke gripper | Precision grippers | Micro-gripper

1254047	DHPS-20-A-NO	5,59 kg	15 mm	OK
1254049	DHPS-25-A	5,9 kg	15 mm	OK
1254051	DHPS-25-A-NC	5,91 kg	15 mm	OK
1254050	DHPS-25-A-NO	5,91 kg	15 mm	OK
1254052	DHPS-35-A	6,48 kg	25 mm	OK
1254054	DHPS-35-A-NC	6,54 kg	25 mm	OK
1254053	DHPS-35-A-NO	6,54 kg	25 mm	OK
1254039	DHPS-6-A	5,22 kg	4 mm	Not OK

Product image



Options

- 2D/3D view
- Accessories
- Data sheet
- Documentation
- Add to basket

★ Core product range

Type

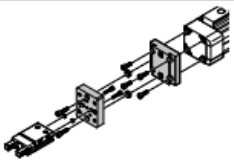
	Results			Max. possible	
Required static retention force	78.48	N	19%	410.95	N
Required dynamic retention force	94.48	N	22%	410.95	N
Intermediate distance of the pressure point	40	mm	40%	100	mm
Dynamic longitudinal force on the gripper fingers	25.51	N	25%	450	N
Dynamic lateral force Mx	0	Nm		50	Nm
Dynamic transversal force My	0.05	Nm		50	Nm
Dynamic lateral torque Mz	0	Nm		50	Nm

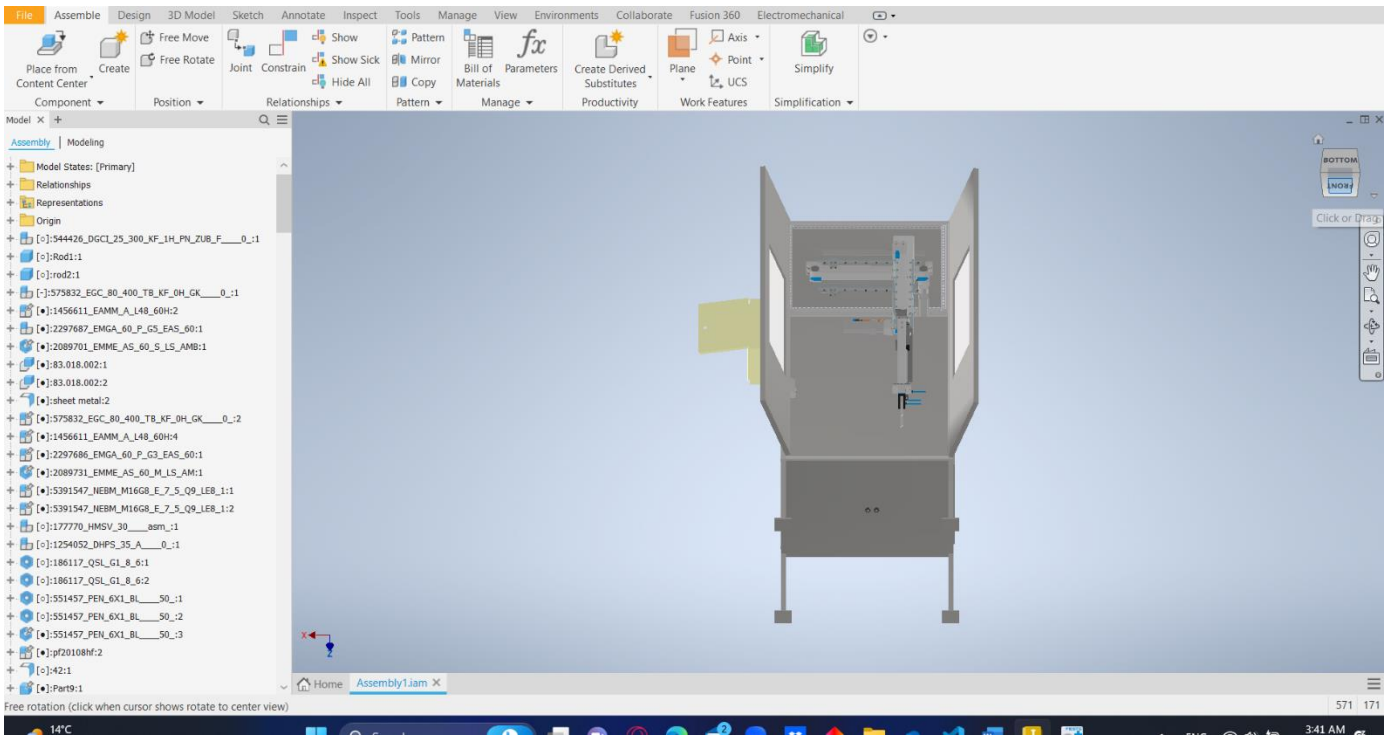
Back

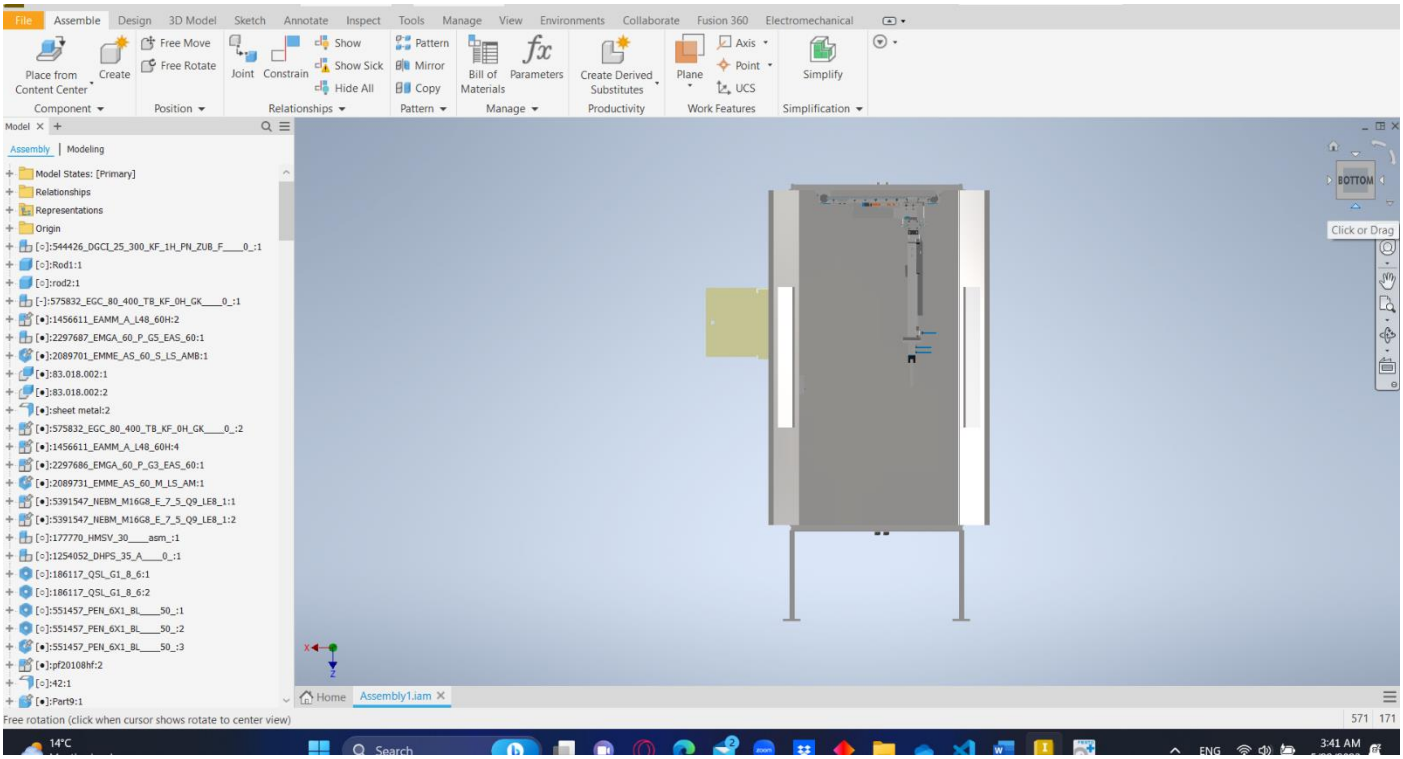
necessary mounting material.

Permissible drive/gripper combinations with adapter kit

Download CAD data ➔ www.festo.com

Combination	Drive Size	Gripper Size	Mounting option		Adapter kit CRC[1)]	Part no.	Type
DGPL/DHPS	**DGPL**	**DHPS**			**HMVA, HAPG, HMSV**		
	**Dovetail mounting**						
	25	10	■	■	2	196788	HMVA-DLA1 8/25
						177767	HMSV-27
	40	10	■	■		196790	HMVA-DLA40
						177767	HMSV-27
	25	16	■	■		196788	HMVA-DLA1 8/25
						177768	HMSV-28
	40	16	■	■		196790	HMVA-DLA40
						177768	HMSV-28
	40	25	■	■		196790	HMVA-DLA40
						177769	HMSV-29
	40	35	■	■		196790	HMVA-DLA40
						177770	HMSV-30

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Assemble
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Collaborate
Fusion 360
Electromechanical
Place from Content Center
Create
Free Move
Free Rotate
Joint
Constrain
Show
Show Sick
Hide All
Pattern
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Copy
Bill of Materials
Parameters
Create Derived Substitutes
Plane
Axis
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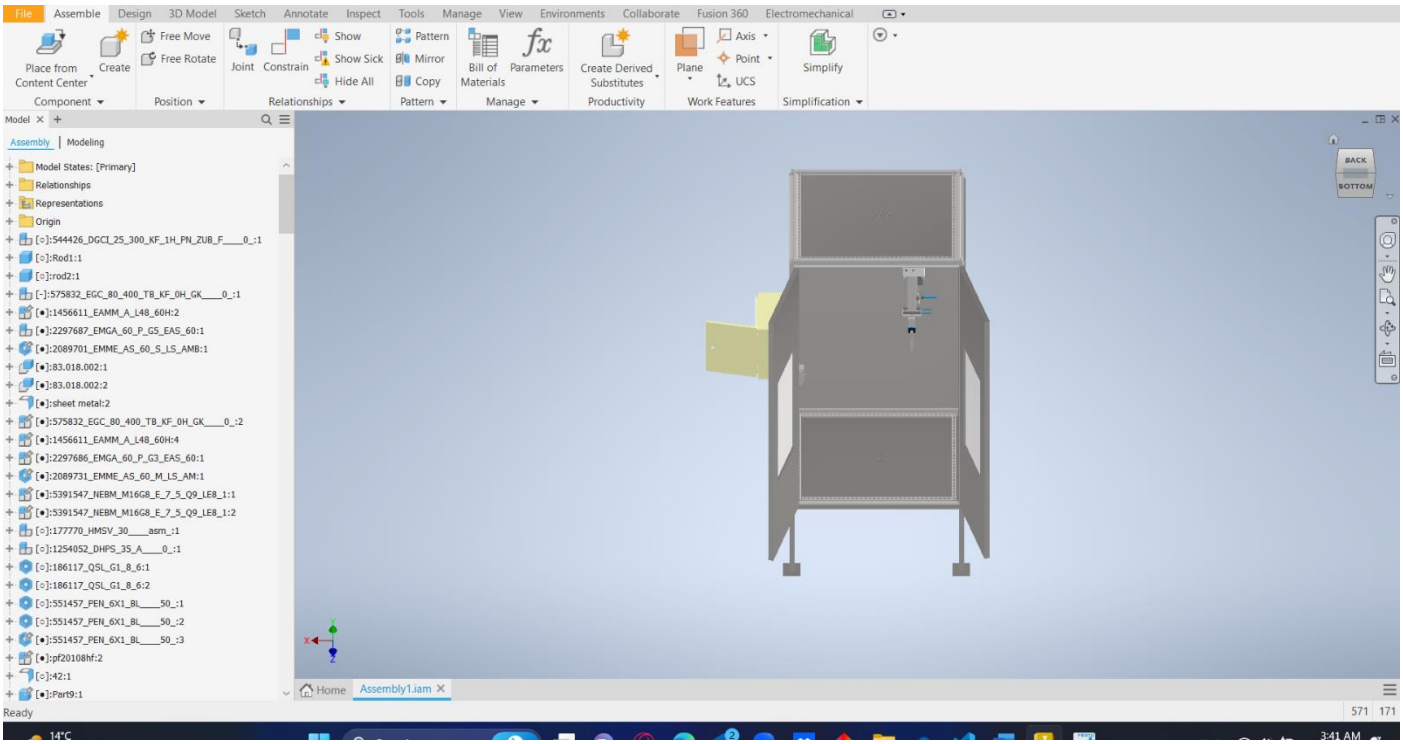
UCS
Simplify
Component
Position
Relationships
Pattern
Manage
Productivity
Work Features
Simplification
Model
Assembly
Modeling
Model States: [Primary]
Relationships
Representations
Origin
BOTTOM
Click or Drag
Home
Assembly1.iam
Free rotation (click when cursor shows rotate to center view)
571
171
14°C
Search
ENG
3:41 AM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Simplification
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Relationships
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Origin
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BOTTOM
Home
Assembly1.iam
Ready
571
171
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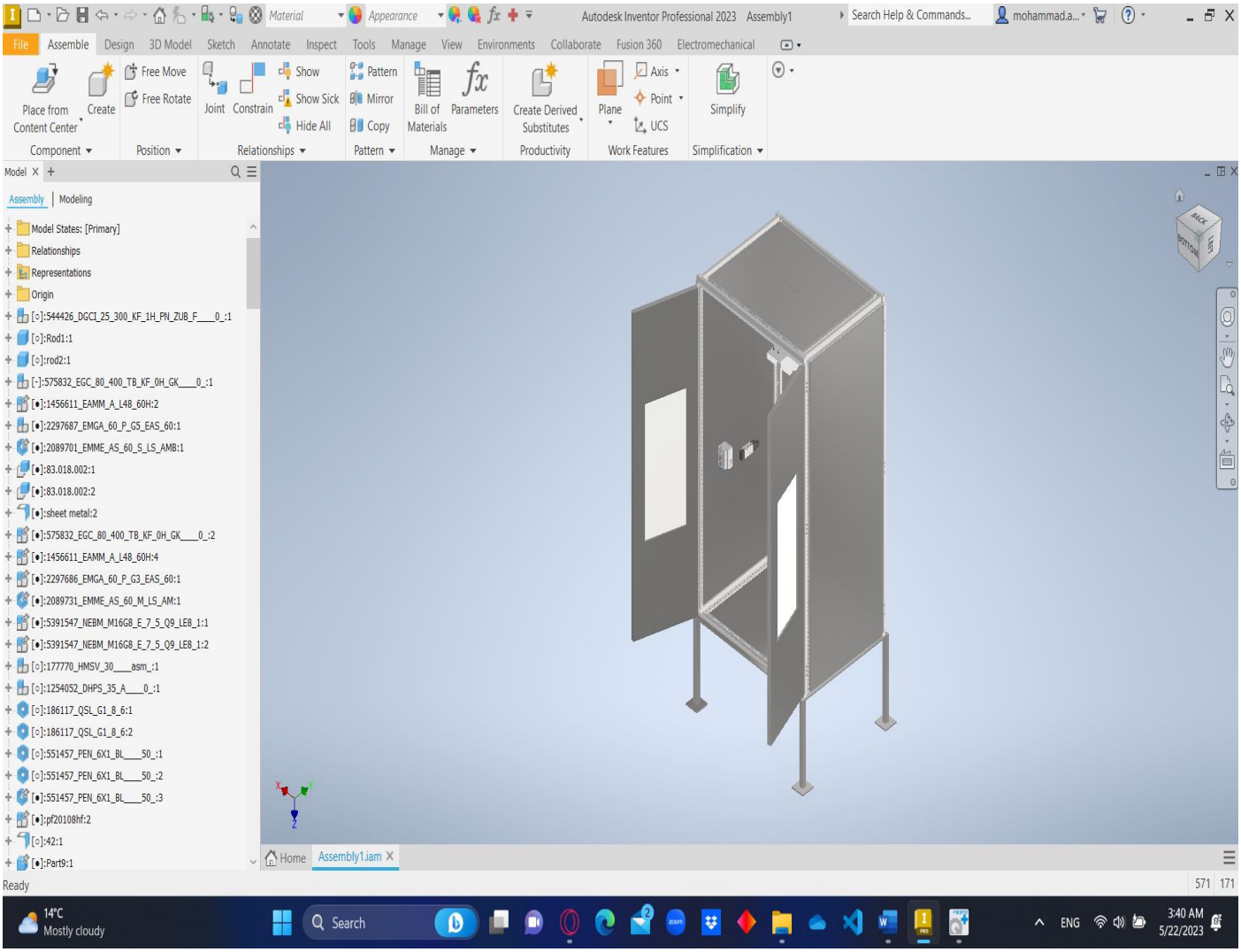
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Appearance
Autodesk Inventor Professional 2023 Assembly1
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Create Derived Substitutes
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Mostly cloudy
Search
ENG
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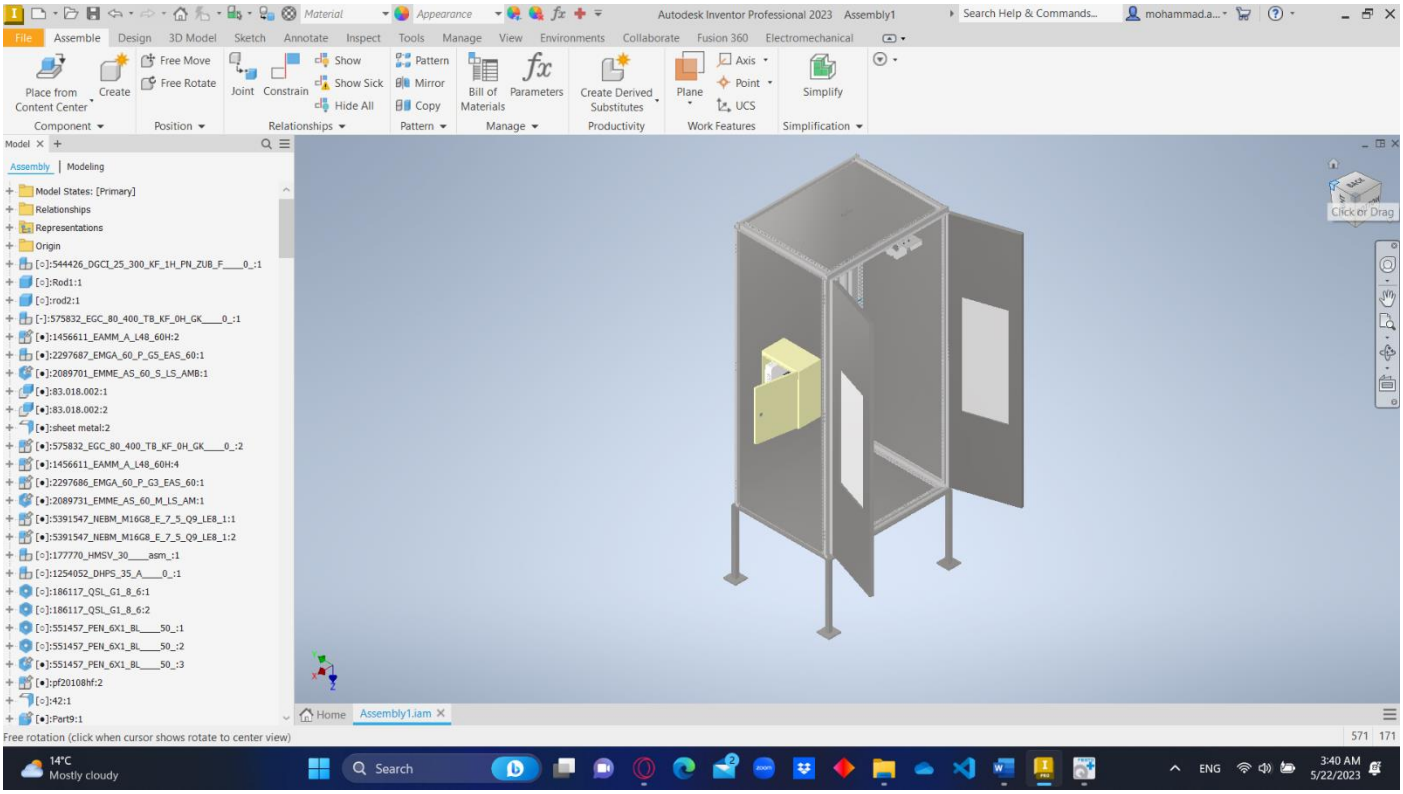
5/22/2023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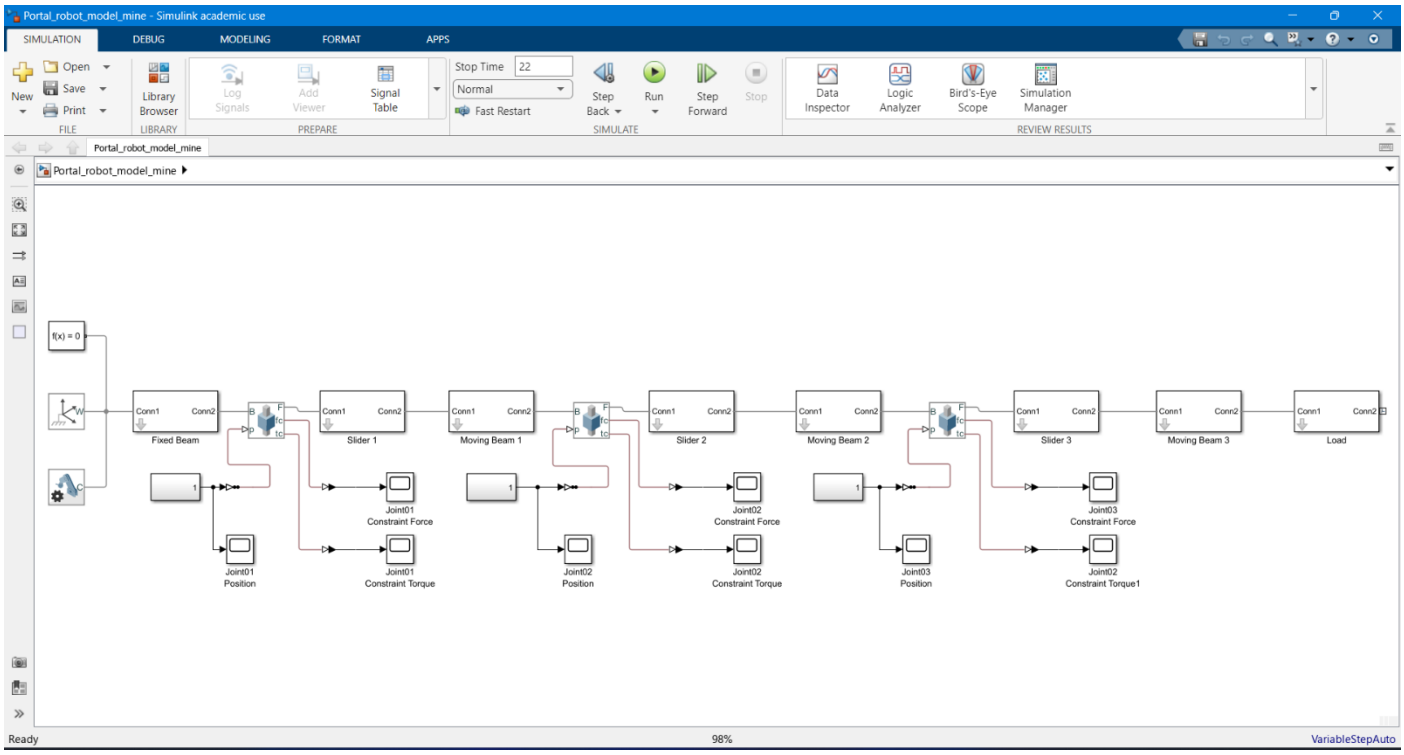
Portal_robot_model_mine - Simulink academic use
SIMULATION DEBUG MODELING FORMAT APPS
New
Open
Save
Print
Library Browser
Log Signals
Add Viewer
Signal Table
Stop Time 22
Normal
Fast Restart
Step Back
Run
Step Forward
Stop
Data Inspector
Logic Analyzer
Bird's-Eye Scope
Simulation Manager
FILE
LIBRARY
PREPARE
SIMULATE
REVIEW RESULTS
Portal_robot_model_mine
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Fixed Beam
Slider 1
Moving Beam 1
Slider 2
Moving Beam 2
Slider 3
Moving Beam 3
Load
Joint01 Constraint Force
Joint01 Position
Joint01 Constraint Torque
Joint02 Constraint Force
Joint02 Position
Joint02 Constraint Torque
Joint03 Constraint Force
Joint03 Position
Joint02 Constraint Torque1
Ready
98%
VariableStepAuto