

# Application Note – Feedback Control Tuning with Motion Manager 6.3 or higher

# Summary

To get the best performance out of your positioning system the feedback control parameters of the FAULHABER Motion Controller have to be adjusted to the application.

This application note describes the tuning of the feedback control parameters of the FAULHABER Motion Controllers via Motion Manager 6.3 or higher.

# Concerning

The following products: MC5010, MC5005, MC5004 and MCS

# Content

- Page 2 Motivation Goals of the Tuning
- Page 5 Prerequisites for Feedback Control Tuning
- Page 7 Feedback Control Tuning the Tool the software tool will be explained
- Page 11 Step by Step Instruction the actual Tuning is done here!
- Page 20 Appendix with Troubleshooting, Expert Tuning and additional hints

Additional information and details have a green colored background.

An Overview of the next tuning steps is marked with a blue background color.



# Motivation

This application note provides a step by step instruction how to tune the controllers in an efficient way, which reduces the commissioning time significantly compared to a trial and error approach.

First of all you should have a clear idea of your own tuning goals.

Controller Tuning can have different goals, for instance:

- Reaching the target position without overshoot
- Fast command response
- Good disturbance rejection
- Silent motor run
- ...

The individual goals have to be weighted, as not all can be achieved with the same set of parameters. A system which is tuned for high dynamics will not necessarily run very silently at the same time.

### Tuning goal of this application note

This application note focuses on the tuning goal of "fast command response with very little or no position overshoot". In addition the underlying velocity loop will be tuned to minimize disturbances, with a focus on positioning applications, like x-y stages, which would benefit from these criteria.



# **Motivation - Continued**

### The Feedback Control System

The Motion Controller mentioned above uses a cascaded feedback control structure, consisting of a subordinated current controller, a velocity controller and a superimposed position controller.



Figure 1: Control cascade

The position controller consists of a proportional controller with a parameter  $K_v$ . The velocity controller uses a PI-structure with a proportional gain  $K_p$  and a reset time  $T_N$ . The current controller uses a PI- controller as well. In addition feedforward values can be applied (not shown in figure 1). This results in an excellent command behavior and a minimal following error.

Background information: Comparison of PID-controller / Controller cascade

PID- Position controller, as well as in the drive business widely used cascaded controllers, show a very good control performance. One of the main differences is the naming of the single control parameters. For instance the proportional gain  $K_P$  of the velocity controller has the same effect as the Derivate term of a PID-Position Controller. Both amplify a velocity deviation, which increases the system damping to a certain point.

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# **Motivation - Continued**

When is it necessary to tune the controller?

- To achieve certain tuning goals
  - To get the best performance out of your positioning or velocity controlled system, achieving certain tuning goals, the feedback control parameters have to be adjusted to the application.



Figure 2: Dynamic Positioning with little overshoot



# **Prerequisites for Feedback Control Tuning**

The Tuning methods introduced in this application note require the system to fulfill the following conditions:

- The system has to be complete, including the power supply
  - If there will be any significant system changes the feedback control tuning has to be repeated.
- The motor has to be set using the motor selection wizard

Motor type:	Rrushless DC Mator
Series:	
Types:	024BX4
	Create a new motor
	<u>View motor data</u>

Figure 3: Wizard for motor selection

- Here the current controller will be adjusted automatically based on the motor data. It is not meant to be tuned manually. Incorrect current controller settings will damage the motor or the power stage.
- In addition the overvoltage threshold is set according to the voltage supplied to Umot (see page 25 for details).



# **Prerequisites for Feedback Control Tuning - Continued**

- The load inertia reflected to the motor (=  $J_{Load}$ ) has to be set using the **controller configuration wizard** 

igure cont	roller / the mo	omento	of inerti	a of the	moving	load			
J <sub>Load</sub> = J <sub>Mot</sub> =	60 63	gcm² gcm²	Mass m Rotor in	oment of i iertia of m	nertia redu otor	ced to mo	tor:		
Alternative Factor o	ely, the mo	oment of	inertia car	h also be estimated by $I_{J} = \frac{J_{LC}}{J_{LC}}$	stimated: ad + J <sub>Mot</sub>	= 2			
-0									1
						Back		Next	Cancel

Figure 4: Wizard for controller configuration

- The inertia factor  $K_J = \frac{J_{Motor} + J_{Load}}{J_{Motor}}$  is essential for the basic parameter set of the velocity loop. The Motion Manager sets the time constant of the velocity feedback filter depending on  $K_J$  as well. Therefore the inertia factor  $K_J$  has to be chosen carefully, or if the automatic system identification wizard is used the result should be checked for plausibility.  $K_J$  should be provided with an accuracy of +/- 20%.
- In addition the Motion Manager calculates appropriate profile parameters based on the inertia of the system.
- **Position limits** have to be activated
  - Before feedback control tuning, position limits (e.g. software limits or limit switches) have to be activated, if the application is limited in its range of movement.
  - An example on how to set Software Limits is found on page 24
- The Load inertia should be constant see page 23
- The mechanical setup should be sufficiently stiff see page 23



# Feedback Control Tuning – the Tool

The Tool offers support to tune the velocity controller and the position controller. In a cascaded control structure the inner loop always has to be tuned first, then the outer loop. This means even position-based systems must first have their velocity loop tuned. The performance of the system highly depends on a well-tuned velocity controller.

#### **Recording - Velocity-View**

The performance of a drive system is evaluated on the basis of a step response.

The Tuning Tool offers the possibility to command a velocity value via the box Setpoint. The button "One Step Response" starts the movement and triggers the recording. The parameter  $K_P$  can be tuned with a slide control.

#### Setpoint

Often 1000 rpm (related to the motor) is a suitable set point. Make sure the checkbox "Move to current position" is activated, so the system will move back, after recording a step response.



Figure 5: Feedback Control-Tuning – the Tool – Velocity-View



# Feedback Control Tuning – the Tool – Continued

### **Recording - Position-View**

 $K_{V}$ , the position control parameter, can be tuned with a slide control.

#### Setpoint

The set point is stated in increments and operates relative to the actual position. During the first tuning steps short distances like <sup>1</sup>/<sub>4</sub> motor revolution should be chosen.

You may choose to have the motor return to the starting point after each move.

	Analog Hall Sensors	Incremental-Encoder with 512 Pulses	AES-4096
1 Motor-Revolution**	4096 Increments	2048 Increments*	4096 Increments

\* Due to four edge / quadrature evaluation one motor revolution equals four times the number of pulses

\*\* If the factor group settings are still in delivery state

Controller tuning (for operating modes with profile generator)	
🚯 <u>Step-by-step instructions</u>	
Recording	
Target: Position (relative)  Position View	
Setpoint: 1024 🚔 incr.	
Target corridor: ± 40	
Act. value: -1419 incr.	
Record step response =	
Va One step response	
Continuous	
Move to current position again	
Recording duration	
V Automatic 500 ms	
Data sources to be recorded ms	
V Position actual value (0x6064.00)	4
Position demand value (0x6062.00)	
Values are sent immediately after a change!	Advanced
Velocity controller: Gain KP (0x2344.01)	
20/4 As x 10^-4	
$0.1 \times 0.2 \times 0.3 \times 1 \times 2 \times 5 \times 10 \times 1 \times = 20/4 \text{ As } \times 10^{-4}$	
Position controller: Gain Kv (0x2348.01)	
Since Control for K <sub>V</sub> adjsutment	
<b>1x:</b> Corresponds to the value, which is determined for the factor of inertia $KJ = 2$ in the <u>controller configuration</u> .	

Figure 6: Feedback Control-Tuning – the Tool – Position-View



# Feedback Control Tuning – the Tool – Continued

### **Analysis View**

The Analysis View offers the possibility to switch between the different recorded step responses. In addition the parameter settings corresponding to the displayed step response are shown. The parameters can be loaded to the Motion Controller and saved "permanently".

Controller tuning (for operating modes with profile generator) 👜 🌐 ? Step-by-step instruction Recording Analysis Analysis View - Velocity actual value — Velocity demand value 📒 Target corridor Step response 1.300 Velocity Target: 1.200 1000 1/min Setpoint: 1.100 32 1/min Target corridor: 1.000 900 Analysis 800 Control rise time: 9 ms 700 /min/ Control settling time: 47 ms 600 500 264 1/min Overshoot: 400 Comparison 300 200 0 100 Transmit control parameters 1 Save control settings "permanently" 84 90 96 102 108 114 120 126 132 138 144 ms Þ • 111 Ts = 0,30msController parameters at the time of recording: M Advanced Velocity controller: Gain KP (0x2344.01) 3272 🔶 As x 10^-4 5x 10x **1x** = 2074 As x 10^-4 0.1x 0.2x 0.5x **1**x 2x Position controller: Gain Kv (0x2348.01) \_\_\_\_\_ 24 🔶 1/s 0.1x 0.2x 0.5x **1x** 2x 5x 10x **1x** = 24 1/s 1x: Corresponds to the value, which is determined for the factor of inertia KJ = 2 in the controller configuration.

This View is only available if at least one step response was recorded.

Figure 7: Feedback Control-Tuning - the Tool - Analysis-View



# Feedback Control Tuning – the Tool – Continued

#### Recording Duration:

Initially "recording duration" is set to "automatic". When this setting is active the motion manager will automatically estimate the time needed for the commanded move.

#### Velocity view

Be aware that the movement of the drive depends on the recording duration and the commanded velocity. This means a drive will move about 3 motor revolutions when a velocity of 1000 rpm is commanded and the recording duration is set to 150 ms.

Controller tuning (for operating modes wit	n profile generator)	
🤣 🙆 🖶 🌐 🕎 🗸		
<u>Step-by-step instructions</u>	₽ 🔺 🖷 🖬 💈	
Recording		
Target: Velocity		
Setpoint: 1000 1/min		
Target corridor: ± 32 📩 1/min		
Act. value: 1 1/min		
Record step response		
😵 One step response 😑		
Continuous		
Move to current position again		
Percording duration		
Automatic 150 ms	Recording duration	
Data sources to be recorded	ms	
Velocity demand value (0x606B.00)	×	4
		m Adupp and
Velocity controller: Gain KP (0x2344.01)	074 As x 100-4	
	x = 2074 Ac x 10.4	
	x - 2017KSX10 -	
Position controller: Gain Kv (0x2348.01)	A 1/c	
	T I/S	
U. X. U. ZX U. XX XX ZX JX IX I	εμ τ2 - A	
1x: Corresponds to the value, which is determine	ed for the factor of inertia $KJ = 2$ in the <u>controller configuration</u> .	
· ·		

Figure 8: Feedback Control-Tuning – the Tool – Recording duration



# Step by Step Instructions – Velocity Controller Tuning

Traditionally the performance of a feedback control system is determined by the evaluation of step responses.

For the velocity controller the goal is a good disturbance rejection. The Set-up wizards already set the reset time  $T_N$  – which usually does not have to be adjusted further. The proportional gain  $K_P$  is available for fine tuning.

A setting which contributes to the goal "good disturbance rejection" always produces a high overshoot of the velocity, if the command value changes rapidly. The overshoot will typically be about 40%.

Figure 9 shows the step response of a well-tuned velocity controlled system. The system should be well-damped, which means the second overshoot (see figure 9 – red rectangle) should be quite small and the system should settle afterwards. This goal is achieved by increasing the proportional gain  $K_P$ .

The position controller will also highly benefit from the damping introduce here, because it allows higher dynamics.



Figure 9: Ideally tuned velocity step response - simulated (MATLAB®/SIMULINK®)



## Velocity Controller - Tuning

## **Overview of Velocity Controller Tuning - Step by Step:**

### Tune $K_P$ - based on the step response

### Tune K<sub>P</sub> - based on the step response

- Set the setpoint value to 1000 rpm
- Make sure the checkbox "move to current position again" is activated
- Make sure the "recording duration" is set to automatic
- Record step responses and gradually increase Kp using the slider until the system is well-damped (see figure 9 on page 11, evaluation of the second overshoot)

The following table shows expected reasonable ranges of the  $K_P$ -factor (1.5x, 3x..) based upon the feedback sensor type. The gain factor 1x is based on the value determined by the start-up wizards.

		Optical	Magnetic
	Analog Hall Sensors	Incremental-Encoder	Incremental-Encoder
<b>К</b> Р	1.5x 3x	3x5x	1.5x5x

The higher the inertia factor  $K_J$  the smaller the possible gain factor (at the same time the absolute value of  $K_P$  increases with  $K_J$ ).



### **Expected tuning results:**

- The first overshoot will reach about 110..135% of the commanded value
- The first overshoot will be reduced (by approx. 50..250 rpm, compared to Kp = 1x)
- The second overshoot should be quite small (comparable to the remaining ripple) and the system should settle in the corridor afterwards as shown in figure 10.



Figure 10: well-damped step response, 3268Bx4 with load disc of 60 gcm<sup>2</sup> (KJ=2), KP = 2x = 4148 As e-4



Figure 11: Moderate step response, 3268Bx4 with load disc of 60 gcm² (K<sub>J</sub>=2); K<sub>P</sub> = 1.4x = 2900 As e-4

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### Option: Supplement to velocity tuning for K<sub>J</sub> >4, using analog hall sensors

### Check the adjusted K<sub>P</sub> value based on the stability limit

If an oscillating instability is not an issue for the system, this option can be used to check if the  $K_P$  value adjusted during velocity tuning is set in a safe distance from the stability limit. Especially if the inertia factor  $K_J$  is large this approach can be helpful.

- Command a step response now the feedback controller is active
- Increase K<sub>P</sub> during standstill with the slide control until the clearly audible stability limit is reached. The value found with this approach be K<sub>P\_critical</sub>
- Reduce K<sub>P</sub> immediately
- The final  $K_P$  value should not exceed a range of 0.5..0.7 x  $K_{P\_critical}$ , if necessary reduce the  $K_P$  value which was found during velocity tuning



# Step by Step Instructions – Position Controller Tuning

As the positon control loop encompasses the velocity control loop (as shown in figure 1), the positon control loop's performance ultimately depends upon the performance of the velocity control loop. In other words, the velocity control loop must be tuned before the position control loop, if not tuned yet, please go back to page 11.

The desired result of position controller tuning in this application note is a fast response with little to no positional overshoot. The section shows how to use  $K_v$  for tuning the Position Control Loop.

# **Position Controller Tuning**

**Overview of Position Controller Tuning - Step by Step:** 

Step 1: Adjust Max Motor Speed

**Step 2: Tune Kv – based on the Step Response - commanding small distances** 

Step 3: Configure the following error as a quick stop source

Step 4: Check the settings - commanding longer distances

### Step 1: Adjust Max Motor Speed

#### Max Motor Speed

If the motor must not exceed a certain velocity in the application, the parameter Max Motor Speed should be set accordingly. This might be useful when using a gearbox for instance, since its appropriate input velocity is usually limited.

See configuration / control parameters / profile parameters

IIII Control parameters	<b>=</b> ×
🗎 🌐 👁 📳	
Position Velocity Current	Profile parameters
Values are sent immediatel	y after a change!
Motion profile type:	Linear ramp 🔹
Max motor speed :	32767 1/min
Profile velocity:	4000 1/min
Profile acceleration:	2700 1/s²
Profile deceleration:	810 1/S <sup>2</sup>
Quick stop deceleration:	30000 1/s²



### Step 2: Tune K<sub>v</sub> – based on the Step Response - using small distances

- Set the setpoint value to 1/4 motor revolution (see also page 8)
- Record step responses and gradually increase K<sub>V</sub> until the desired dynamic is reached
- If the graph of the actual position shows slight oscillations, it is usually not useful to further increase  $K_{\rm V}$
- If the system shows some oscillation in the final position, K<sub>V</sub> has to be reduced again
- Save the determined parameter  $K_V$  "permanently"

The following table shows expected reasonable ranges of the  $K_v$ -factor value (2x, 5x.) based upon the feedback sensor type. The gain factor 1x is based on the value determined by the start-up wizards.

		Optical	Magnetic
	Analog Hall Sensors	Incremental-Encoder	Incremental-Encoder
Kv	2x 5x	5x10x	2x10x

Systems that function well on the higher end of the range of the  $K_P$ -factor (see page 12) will most likely function well on the higher end of the range of the  $K_V$ -factor.



### **Expected tuning result:**

- Figure 13 shows a well-tuned system without overshoot
- The step response should show a constant following error in the range of 5..20 ms





Setpoint =  $\frac{1}{4}$  Motor revolution; K<sub>v</sub> = 140; Rising time = Settling time = 39 ms; K<sub>J</sub> = 2;



Figure 14: Not a dynamic positioning

Setpoint:  $\frac{1}{4}$  motor revolution; K<sub>v</sub> =56; Rising Time = Settling Time = 68 ms; K<sub>J</sub> = 2;



### Step 3: Configure the following error as a quick stop source

Before commanding longer distances it is highly recommended to configure the following error as a quick stop source. This prevents the system from instabilities.

This recommendation is based on the protection functions of the Motion controller which limit the available current, when

- the thermal models exceed a certain temperature (motor or power stage)
- an overvoltage is detected during braking

Especially if the inertia factor  $K_J > 3$  a limitation of the current, may cause an instability.

In addition, if the Profile Velocity parameter is considerably too high, and a large distance is commanded, this can lead to instability as well.

Any instability can be prevented using the following error as a quick stop source.

See Drive Functions / Device Control for easy configuration of the error handling. There the following error can be configured as "Quick Stop" source.

brive functions							X
Operating modes     Device control     Motion profile	<ul> <li>Device control - Error has</li> </ul>	andling					
- Position limits	Error mask (0x2321)						
Factor group     Fror handling     Sequence programs     Ambient parameters     Signal management     Communication	Mask         Error           0x0001         Speed deviation error           0x0002         Following error           0x0004         Over voltage error           0x0005         Under voltage error           0x0006         Uren voltage error           0x0010         Temperature warning           0x0020         Temperature error           0x0040         Encoder error           0x0080         Internal hardware error           0x0100         Module error           0x0200         Current measurement error           0x0800         Communication error           0x0800         Calculation error	BMCY BMCY				Quick Stop	
	Se	nd	Save	(	Close	Help	

Figure 15: Drive Functions / Device Control / Error handling



# Step 4: Check the settings - commanding longer distances

- Restart the Tuning Tool
- Set Setpoints relevant for the application (distance wise)
- Modify K<sub>V</sub>, if necessary
- Modify the Profile Velocity (see "Advanced" settings), if necessary
- Save the determined parameters "permanently"

After following the steps 1..4, the position controller tuning is completed.



# **Appendix - Troubleshooting**

### a) Position course with slight tendency for oscillations

- Increase the Proportional gain  $K_P$  of the velocity controller by 5..10 % (Keep the stability limit in mind)
- Decrease the profile velocity value, see also g)
- Decrease the Proportional gain  $K_V$  of the position controller

### b) Dynamics – Settling Time is too high, no oscillations

- Increase the Profile Acceleration and repeat step 4 of the position control tuning
- For longer distances: It might be possible to increase the Profile Velocity, see also g)
- See also f) Feedforward and d) further factors

### c) Tuning rules do not seem to work

- Check if the correct motor was chosen in the motor selection wizard
- Check if the correct inertia factor K<sub>J</sub> was set (see page 6)

### d) Additional Factors influencing the dynamics

- A power supply capable of handling regenerated energy or a brake chopper can increase the dynamics
- Chose a mechanical setup with a small inertia factor  $K_J = \frac{J_{Motor} + J_{Load}}{J_{Motor}}$ ; Ideally  $K_J < 4$
- If K<sub>J</sub> > 4 consider using a larger motor, or the use of a gearbox to reduce K<sub>J</sub>, to get a higher stability margin or higher performance. The load inertia seen by the motor  $(J_{Load\_Reflected})$  is reduced by the square of the reduction ratio using a gearbox  $\rightarrow J_{Load\_Reflected} = \frac{J_{Load}}{i^2}$

### e) OverVoltage Error

- In order to ignore otherwise safe transient voltage spikes, it might be necessary to increase the Delay Time 0x235.05, see page 25



# **Appendix – Expert Tuning**

### f) Path Accuracy and Dynamics – Feedforward for Position Control

This approach shall increase the path accuracy by using **Velocity Feedforward** and may further reduce the settling time:

- First, the Step by Step Tuning starting on page 11, ending on page 19 has to be performed, especially the Following error has to be configured as quick stop source (see page 18).
- Only then the Velocity Feed Forward should be activated.

In Position View the Velocity-Feed-Forward-Value should be set to 100 % ( = 128)

/alues are sent immediately after a change!			Advanced
/elocity controller: Gain KP (0x2344.01) 3272 As x 10^-4	Velocity fee	dforward	Velocity feedforward factor (234A.01)
0.1x 0.2x 0.5x 1x 2x 5x 10x 1x = 2074 As x 10^-4	Profile velocity:	4000 1/min	0% 50% 100%
Position controller: Gain Kv (0x2348.01)	Profile acceleration:	2700 🗘 1/s²	Current feedforward factor (0x2349.01)
58 1/s	Profile deceleration:	810 🔷 1/S²	0
0.1x 0.2x 0.5x 1x 2x 5x 10x 1x = 24 1/s			0% 50% 100%

Figure 16: Control and Feedforward Parameters

As a result the following error will be reduced. The settling time might be reduced by 1 to 10 ms, depending on how well the system was tuned before.

Velocity Feedforward might cause a tendency for small oscillations before settling. If this is the case and the tuning goal is to reach the commanded position without any overshoot, it might be helpful to consider current feedforward in addition - see page 22.



Figure 17: Positioning with Feedforward of Velocity



# Appendix – Expert Tuning – Continued

- **Current Feedforward** can be used in addition to Velocity Feedforward. For Current Feedforward to be useful, the inertia factor K<sub>J</sub> should be known within +/- 20%.
- In Position View the Current feedforward value should be set to 80..100% ( = 102..128).

Values are sent immediately after a change!		Advanced	
Velocity controller: Gain KP (0x2344.01)	Profile parameters	Velocity feedforward factor (0x234A.01)	
3272 As x 10^-4	Motion profile type: Linear ramp	0	
$0.1x  0.2x  0.5x  1x  2x  5x  10x  1x = 2074 \text{ As } x \ 10^{-4}$	Profile velocity: 4000 1/min	0% 50% 100%	
Position controller: Gain Kv (0x2348.01)			
58 1/s	Current feedforward	0	
0.1x 0.2x 0.5x 1x 2x 5x 10x 1x = 24 1/s		0% 50% 100%	
<b>1x:</b> Corresponds to the value, which is determined for the factor of inertia $K1 =$	2 in the controller configuration		

Figure 18: Control and Feedforward Parameters

With additional Current Feedforward the tendency for oscillations is likely to be considerably reduced compared to pure Velocity FeedForward. The Following Error is at is minimum.

The settling time might be slightly increased compared to pure Velocity FeedForward.



Figure 19: Positioning with Feedforward of Velocity and Current



# Appendix – Expert Tuning – Continued

### g) Profile Velocity in Detail

The parameter Profile Velocity acts as a limiter on the velocity command generated by the profile generator, chosen properly it helps to reduce the following error.

The longer the commanded distance, the larger is the maximum velocity which the profile generator calculates based on the distance and the acceleration and deceleration parameters.

The drive system may only follow this calculated profile, as long as the supply voltage is high enough to accelerate the inertia, while overcoming any friction and the Back-EMF-voltage at the same time.

The limiting profile velocity comes into play here. A properly chosen Profile Velocity parameter helps to avoid large overshoot or even instability of the system, because the drive system will be able to follow the commanded values. If the limitation applies, this results in a trapezoidal velocity profile.

Values are sent immediately after a change! Advanced Advanced Settings Velocity controller: Gain KP (0x2344.01) Profile parameters A.01) Linear ramp 🔹 🔻 -0-Motion profile type: 0 -0 Profile velocity 0.1x 0.2x 0.5x 1x 2x Profile velocity: 4000 🔷 1/min 0% 50% 100% 2700 🔷 1/S<sup>2</sup> Position controller: Gain Kv (0x2348.01) Profile acceleration: Current feedforward factor (0x2349.01) 0 ▲ ▼ 58 2 1/s 810 2 1/S<sup>2</sup> 0 Profile deceleration: 0.1x 0.2x 0.5x 1x 2x 5x 10x 1x = 24 1/s0% 50% 100% 1x: Corresponds to the value, which is determined for the factor of inertia KJ = 2 in the controller configuration.

See Advanced Settings / Profile parameters / Profile velocity

Figure 20: Profile Parameters

### h) Constant versus Variable Load Inertia

If the load inertia changes significantly, the proportional gain  $K_P$  and possibly the velocity feedback filter have to be changed accordingly to keep the system stable.

### i) Stiff / Elastic Mechanics

For systems with compliance, such as elasticity or high degree of backlash, the proportional gain  $K_P$  of the velocity control loop might have to be reduced. The tuning methods in the application note might not apply in these cases.





# **Appendix – Software Position Limits**

### j) Adjustment of Software Position Limits

Before adjusting Software Position Limits it might be necessary to set the actual position to zero. This can be done via the Motion Cockpit Tool where you can find the Homing modes. Homing Mode 37 can be used to set the actual position to zero.

See Drive Function / Device Control for an access to the Position Limits. There the Software Positon Limits in increments can be adjusted.

Operating modes  Device control  Motion profile	<ul> <li>Device of</li> </ul>	control - Position limits			
-Position limits	Position range limit (0x607B)				
- Factor group	Min position range li	-2147483648 incr.			
- Sequence programs	Max position range li	: 2147483647 incr.			
Ambient parameters	Software position limit (0x607D)				
Communication	Min position limit:	-2147483648 incr.			
	Max position limit:	2147483647 incr.			
	Set range limits by limit	switch (digital inputs)			
	Sond Source	Close Halp			

Figure 21: Drive Functions / Device Control / General

By default the software positon limits apply to modes of operation for positioning only.

If there are no limit switches in use, it is highly recommended to activate the software position limits for velocity controlled modes as well.

This is done by setting Bit 1 of object Operation Mode Options 0x233F to 1.

Operating modes     Operating modes     Operating control     Operating contro     Operating control	<ul> <li>Device control - General</li> </ul>					
	Option Codes Quick-Stop option code: Shutdown option code: Disable operation option code: Hait option code: Fauit reaction option code: Manufacturer specified bits (0x22 Bit mask for bit 14: Bit mask for bit 14: Operation mode options (0x233) Bit Coption	Slow down on quick stop ramp and transit into Switch On Disable drive function (switch-off the drive power stage) Slow down with slow down ramp; disable of the drive funct Slow down on slow down ramp and stay in Operation Enable Slow down on quick stop ramp A) 0x00000000 00 00 00 00 00 00 00 00 00 0	Disabled • • bled • •			
	Use position limits as limits in     Auto enable power stage     Immediate references are reli	speed mode	on limits in	speed mode		
	4 No automatic adjusting of po Value	sition limits Ox0003				
		Send Save	Close Help			

Figure 22: Drive Functions / Device Control / General



# Appendix – OverVoltage Threshold

### k) OverVoltage Threshold

During braking energy is fed back into the power supply. If the power supply is not capable of dealing with regenerative energy, the voltage will increase instead. The Motion Controller will take action to keep the voltage down. A certain voltage threshold triggers the "burning of energy" in the motor and/or the reduction of the current applied for braking.

For a 24V DC power supply with a tolerance of +/- 10%, the "Motor supply upper threshold" should be set around 27V to prevent unexpected shut-down or even damage of the power supply during braking. The motor selection wizard implicitly configures this threshold according to the supplied Umot voltage.

brive functions				
Operating modes     Device control     General	<ul> <li>Device control - Amb</li> </ul>			
Motion profile     Position limits     Factor group     Error handling     Sequence programs     Ambient parameters     Signal management     Communication	Ambient temperature: Reduction of Thermal resistance 2: Overvoltage control Motor supply upper threshold: Voltage error delay time:	22 25 2700 200	°C % x10 mV ms	Overvoltage control
	Send Save	Close	Help	

Figure 23: Drive Functions / Device Control / Ambient parameters

See Drive Functions / Device Control / Ambient parameters for an access to the over voltage threshold: "Motor Supply UpperThreshold".

In addition the possibility to adjust a Delay Time (0x2325.05) is offered. If the Motor Supply Upper Threshold is exceeded for a time longer than this Delay Time the Motion controller will turn off the power stage and will set an over voltage error. When using high load inertia it is likely that the delay time has to be increased.



# Appendix – Non-Profile Modes of Operation

### I) Usage of Non-Profile Modes of Operation

- Cyclic Modes:

By design cyclic modes depend on a stream of command values (and maybe additional feedforward values) from a Master PLC at regular intervals in the range of typically 1 to 10 ms. The control system can be tuned using the tuning tool, but afterwards the profile parameters have to be transferred to the Master PLC for the calculation of the command trajectory.

- Analog Modes:

Analog Modes do not make use of the profile generator either. Instead command filters have to be used. If the Motion Manager Tool shall be used for control tuning, the maximum profile parameter values should be set and a command filter has to be activated.



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