Principles of Positioning

for Stepper Motor Controllers

TRANSLATION OF THE GERMAN ORIGINAL MANUAL

Version	Modification
7	Reference run; start position P10

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In this manual, you will find the feature descriptions and programming a controller for positioning of a stepper motor.

This manual is supplementary to the „phyLOGIC™-Command References“ and „ProfiNet/ProfiBus Interfaces“.

This manual is supplementary to the “*phy***MOTION**™ *Modular Multi-axis Controller for Stepper Motors”* manual.

Every possible care has been taken to ensure the accuracy of this technical manual. All information contained in this manual is correct to the best of our knowledge and belief but cannot be guaranteed. Furthermore, we reserve the right to make improvements and enhancements to the manual and / or the devices described herein without prior notification.

We appreciate suggestions and criticisms for further improvement.

Email address: doku@phytron.de

Questions about the use of the product described in the manual that you cannot find answered here, please contact your representative of Phytron (http://www.phytron.de/) in your local agencies.

1 Legal information

This manual:

Read this manual very carefully before mounting, installing and operating the device and if necessary further manuals related to this manual.

- Please pay special attention to instructions that are marked as follows:

	DANGER – Serious injury!	*Indicates a high risk of serious injury or death!*
	DANGER – Serious injury from electric shock!	*Indicates a high risk of serious injury or death from electric shock!*
	WARNING – Serious injury possible!	*Indicates a possible risk of serious injury or death!*
	WARNING – Serious injury from electric shock!	*Indicates a possible risk of serious injury or death from electric shock!*
	CAUTION – Possible injury!	*Indicates a possible risk of personal injury.*
	CAUTION – Possible damage!	*Indicates a possible risk of damage to equipment.*
	CAUTION – Possible damage due to ESD!	*Refers to a possible risk of equipment damage from electrostatic discharge.*
	”Any heading“	*Refers to an important paragraph in the manual.*

Positioning

Observe the following safety instructions!

Safety Instructions

CAUTION – Possible damage!

Malfunctions are possible while programming the instruction codes – e.g. sudden running of a connected motor, braking etc.

- Please test the program flow step by step.

CAUTION – Possible damage!

For each application, the functional reliability of software products by external factors such as voltage differences or hardware failure, etc. is affected.

- To prevent damage due to system error, the user should take appropriate safety measures. These include back-up and shutdown mechanisms.

CAUTION – Possible damage!

Each end user system is customised and differs from the testing platform. Therefore, the user or application designer is responsible for verifying and validating the suitability of the application.

- The suitability of the device's use must be tested and validated.

CAUTION – Possible damage!

Some modules are set to a default value on delivery. Therefore, e.g., the motor current must be set to the corresponding value (see the motor data from the motor manufacturer). Connected components like motors can be damaged by incorrectly set values.

- Please check before starting, if the parameters are correct.

2 Contents

3 Introduction

*phy***LOGIC**™ is the programming language to communicate with Phytron programmable logic controllers like the MCC-Series or our *phy***MOTION**™.

*phy***LOGIC**™ instructions can easily be sent to the controller with Phytron's programming software (*phy***LOGIC**™ Toolbox) via USB, embedded into other protocols like Ethernet or into interface protocols like ProfiBus / ProfiNet.

You can parameterise your commands (e.g. a driving command) per axis either just the first time you set up your system, or adjust the parameters temporarily before sending a driving command.

Example: For "relative run" you can set: step resolution (P45), run current (P41), run frequency (P14), start stop frequency (P04), ramp (P15), recovery time (P16), boost (P17), boost current (P42), current delay time (P43), etc.

Use this illustration to find the adequate manual for your programming task:

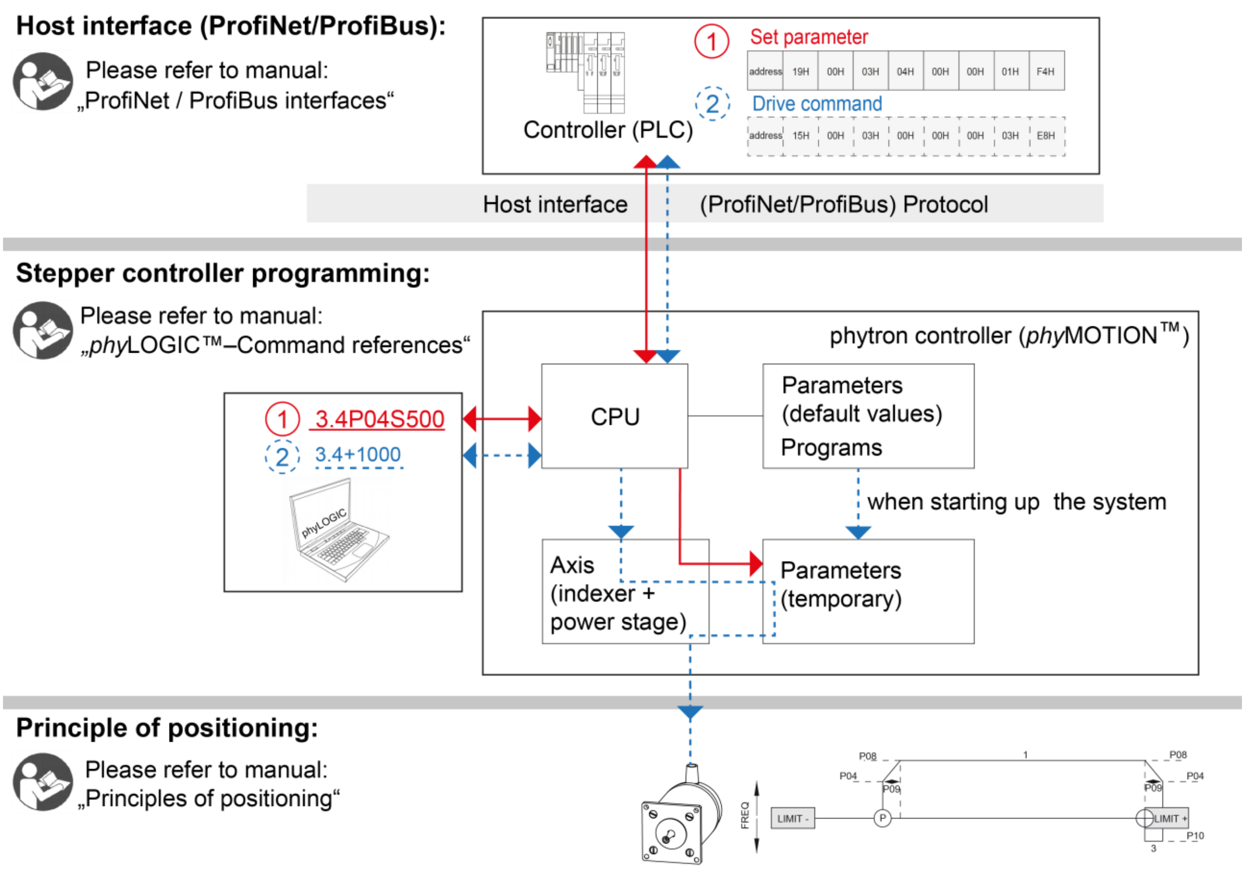


Fig. 1: Illustration for finding the right manual for your programming task

Each of our programmable controllers comes along with preset parameters (default values), which are automatically loaded into the temporary memory of each axis while starting the device. These parameters can be changed during your program is executed to optimise your motion tasks at any time.

If you want your controller to wake up with a new set of parameters, you have to store them in the non-volatile storage of the main CPU unit explicitly by using a certain command.

4 Setting Stepper Motor Parameters

For operating a phytron stepper motor controller several adjustable variables as speed, acceleration ramps or current values are required. These adjustable variables are called **parameters**. E.g., run frequency parameter (P14).

Chapter 6 in this manual contains the complete list of all parameters.

4.1 Velocity Profile of the Stepper Motor Controller

Revolution frequency of the stepper motor

The revolution frequency of a stepper motor is usually indicated in rpm. From the view of the stepper motor module a frequency is displayed at the output terminal (Run frequency P14). The relationship between the speed of the stepper motor (velocity n) and the displayed frequency (P14) is as follows:

P14 = (n x s)/ (60 s/min)

P14= Run frequency in [Hz]

n = Motor speed in [rpm]

s = Full step resolution of the stepper motor (typical: 200 steps/rev). For further information, refer to the technical data for the stepper motor.

General velocity profile of the controller

Normally each incremental move is always carried out by the same velocity profile.

The stepper motor accelerates without a ramp to the start-stop frequency P04. Then the stepper motor follows over a ramp to the desired run frequency P14. The Range 2 is characterized by moving with constant speed. In range 3, the stepper motor is decelerated by a ramp. A system-specific frequency F_{max} limits the maximum speed of the drive system.

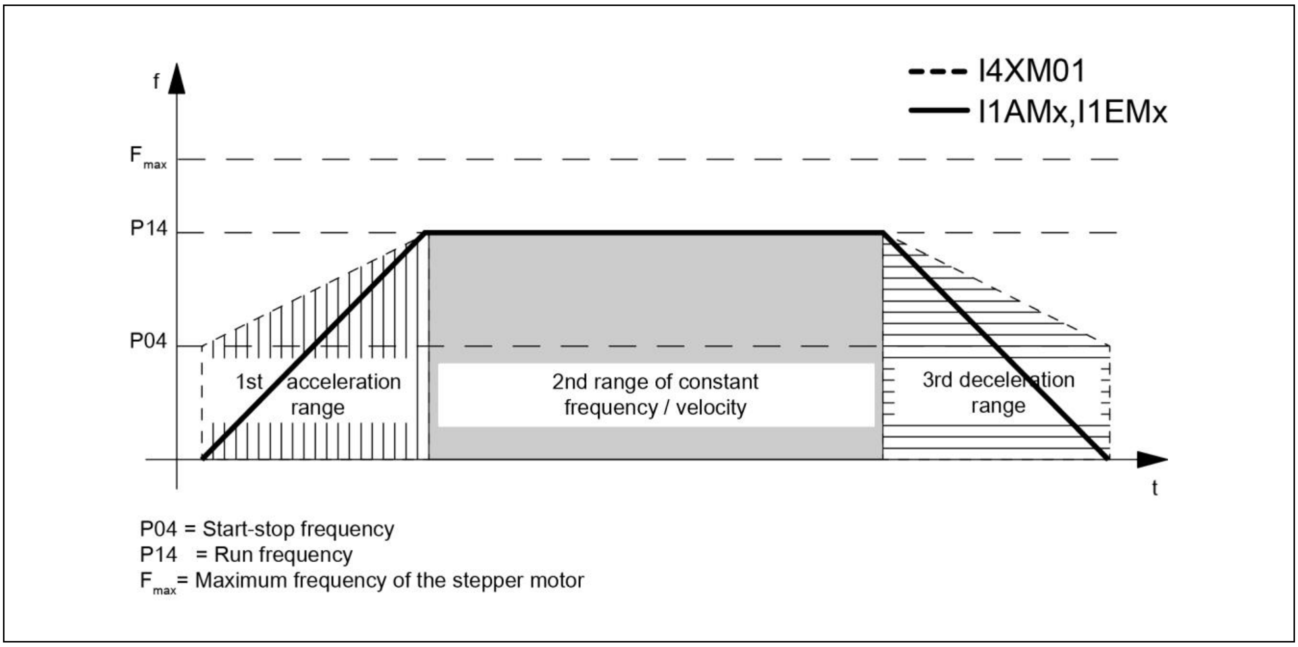


Fig. 2: Motion profile of the stepper motor controller

P04= start-stop frequency
(for P14>P04 I1AM0x or I1EM0x does not use P04 for accelerating)

P14 = run frequency

F_{max}= system-specific, maximum frequency of the stepper motor with a load applied

Run frequency / velocity P14

- *The run frequency can be chosen for each drive.*
- *P14 is always lower than F_{max} and there should be a safety margin between P14 and F_{max}. Phytron recommends a safety factor of 1.4 to 2.*

Setting the run frequency / velocity P14

The run frequency can be set with parameter P14. This parameter is set in Hz. If you have used the formula above to calculate your frequency out of the needed motor velocity – you have a frequency in Hz full step. If you have selected a different step resolution than full step (P45), you have to increase your run frequency by the factor of the step resolution.

Example: If you have selected half step resolution, you have to double your run frequency to achieve the same speed as in full step mode. If you have selected 1/8 step resolution, you have to multiply your full step frequency by 8 etc.

Start-stop frequency P04

The start-stop frequency is the frequency to which the motor can instantly be accelerated under load from a standstill without losing the synchronization of the electrical field and without losing steps.

The maximum start-stop frequency P04 mainly depends on the moment of inertia of the load, as well as on the friction of the system.

If the stepper motor must pass through a frequency range of resonances in the acceleration phase, either a ramp should be configured as steep as possible to pass through the resonance region quickly or the start-stop frequency should be set above the resonance frequency, or the mechanical system could be damped.

- *The parameter P04 has also to be set in Hz.*
- *If your selected speed (P14) is lower than the start-stop frequency (P04) the motor will be accelerated instantly (without a ramp) to the selected speed (P14).*
- *If your selected speed (P14) is greater than the start-stop frequency (P04)*
    - *Your motor connected to the I1AM0x or I1EM0x will accelerate on a defined ramp to the final speed (P14)*
    - *Your motor connected to a high-end indexer like I4XM01 will instantly accelerate to the start-stop frequency (P04) and from there on with a ramp to final speed (P14). This increases the possible speed of movement.*

Maximum frequency / Velocity of the Axis F_{max}

When choosing a stepper motor the maximum frequency/velocity is determined by the application. At this frequency, the motor must reach a torque high enough to move its load.

The maximum frequency F_{max} can be estimated from the corresponding characteristic curve.

Please note that a sufficient large safety margin must be applied.

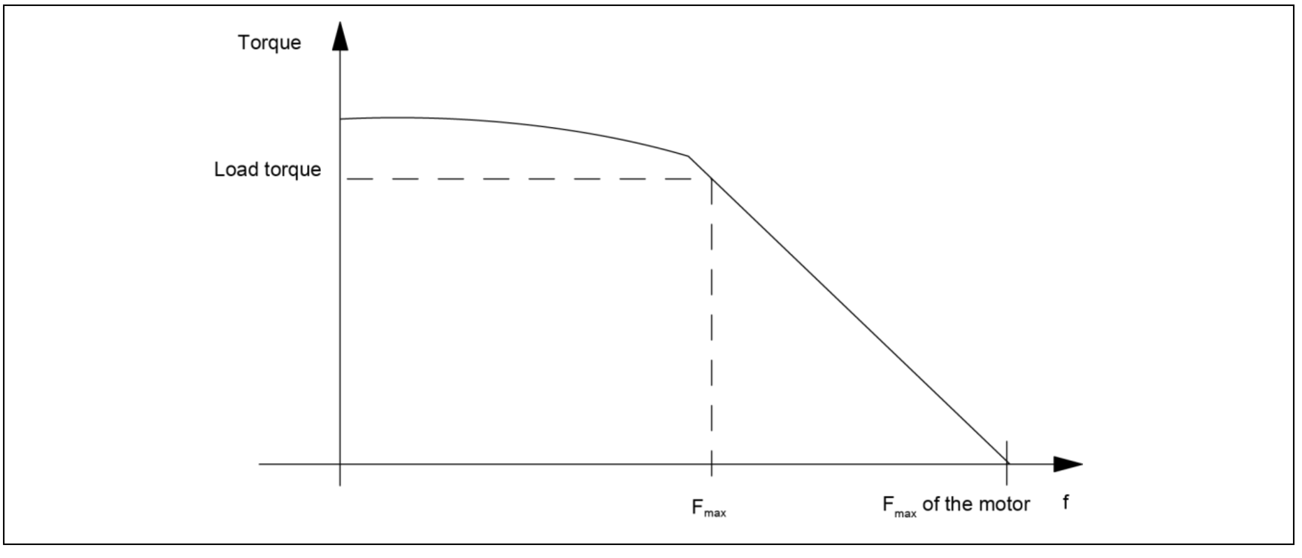


Fig. 3: Torque Characteristic Curve of a Stepper motor

Acceleration / Deceleration ramp a (P15)

The maximum permitted acceleration / deceleration depends on the load to be moved.

The motor must reach a torque high enough to accelerate or delay the load without loss of step.

Depending on the application, you must also take into account additional criteria for setting the acceleration/deceleration, such as smooth starting and stopping.

- *The parameter P15 is also set in Hz.*
- *For the I1AM0x or I1EM0x module: the ramp during acceleration can be set in 4 kHz steps.*

4.2 Phase Currents (Run, Stop, Boost Current)

Three different phase currents can be indicated for the controller: run current, stop current and boost current.

i The selected current is proportional to the created torque of the stepper motor. Therefore, before testing your system, you have to cross check that your current parameters are set properly to not destroy the attached motor or system. Always start with low current settings.

The run current is the one that is produced at a constant velocity (P14) during the run mode. After the motor is brought to a stop we recommend switching to a reduced stop current after a parameterized Run Current Delay Time (t_{DELAY} = P43). This reduces the thermal losses of the motor at standstill and saves power consumption.

While a stepper motor is accelerated or decelerated, it needs more torque and thus more power compared to a pure run with a constant velocity (P14). The torque can then be increased in the phases of acceleration and deceleration by using a boost current (P17, P42).

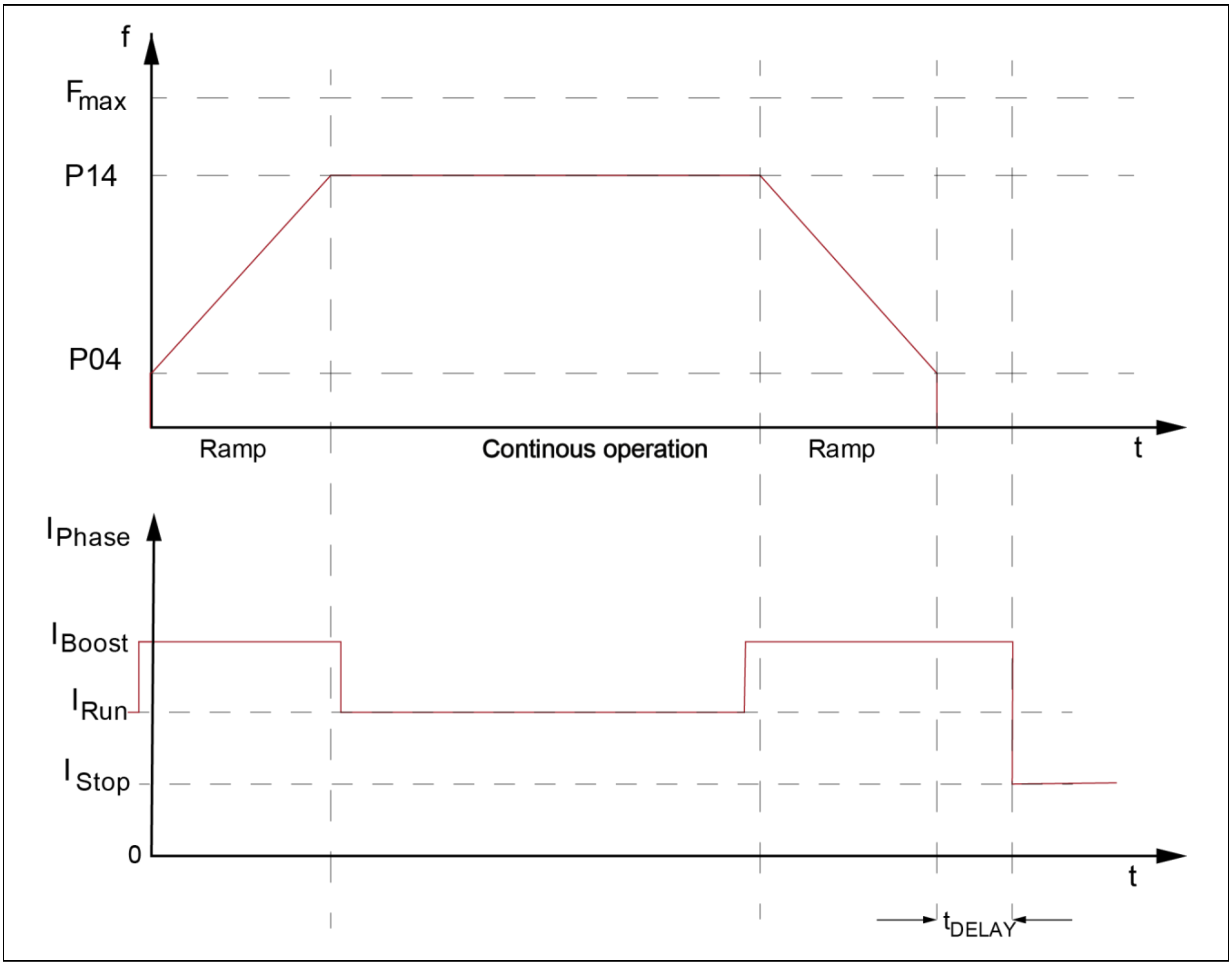


Fig. 4: Velocity profile versus current adjustment at the power stage

According to a time set in the parameter “Current Hold Time” t_{DELAY} (P43) it will be switched to stop current I_{STOPP} (P40) after the run is finished.

For more information, why a current delay time can be necessary, please continue reading in chapter 4.4.

4.3 Step Resolution

Full step

The “full step“ mode is the operating mode in which a 200-step motor, for example, drives 200 steps per revolution. The physical resolution of the motor is achieved in the full step mode. Any further increase of the step resolution (e.g. half step, quarter step, etc.) is done electronically. In the full step mode, both stepper motor phases are permanently energized.

The step resolution can be set with parameter P45.

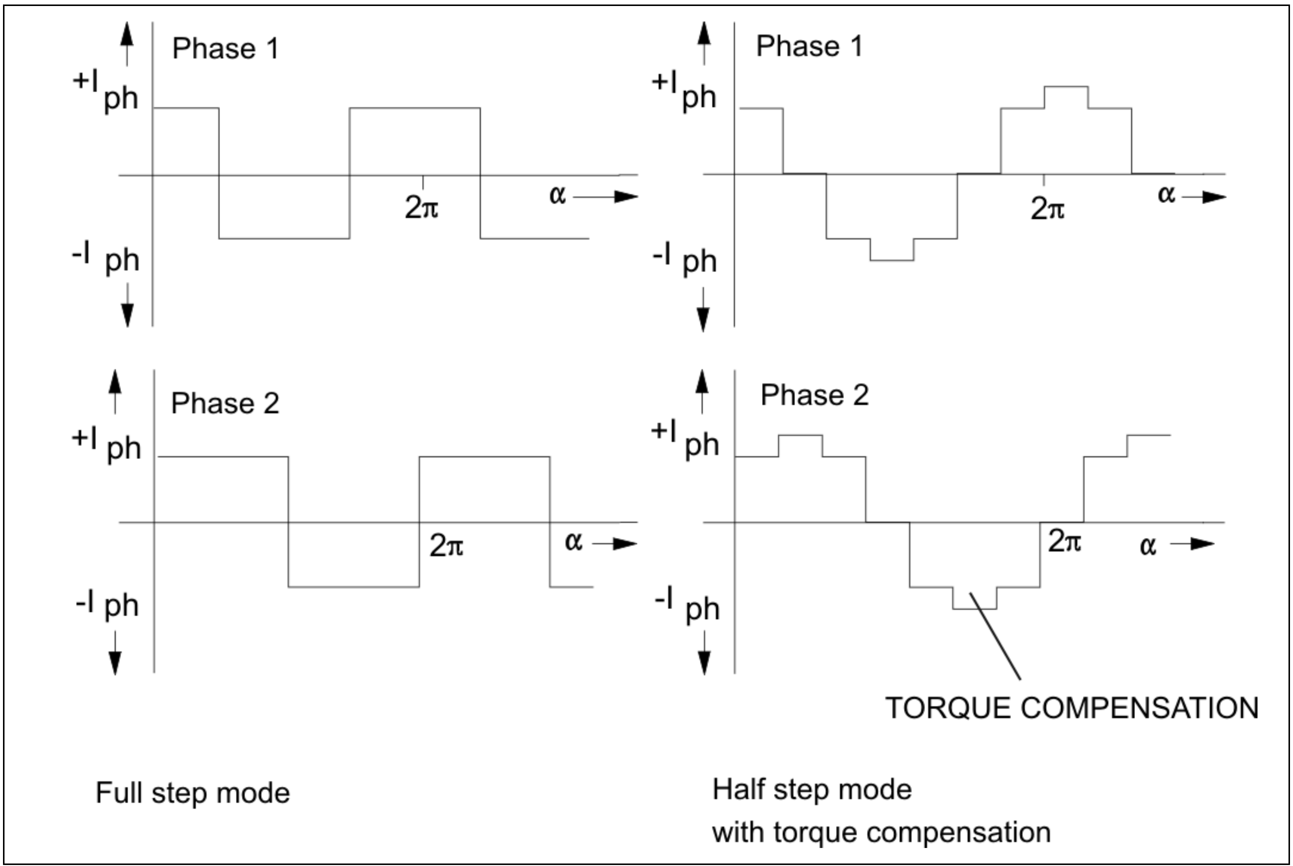


Fig. 5: Phase current curves

Half Step

The motor step resolution can be electronically multiplied by 2 by alternately energizing the stepper motor's phases 1, 1+2, 2 etc. This is the "half step" mode. The torque, however, is reduced in the half step mode, compared to the full step mode.

To compensate for this lack of torque, the operating mode "half step mode with torque compensation" was developed: the current is increased by $\sqrt{2}$ in the energized phase. Compared to the full step mode, the torque delivered is almost the same and most of the resonance is suppressed.

The following diagram shows the magnitude and direction of the holding torques of a 4-step motor during one revolution without and with torque compensation. In the full step position, two phases are energized, in the half step position only one phase is energized. The total torque is the result of the vector sum for any phases that are energized.

The Torque Full Step, M_{FS}, as compared to the torque in the half-step mode is: $|M_{FS}| = |M_{HS}| \times \sqrt{2}$

This means, when a single phase is energized, the current must be increased by a $\sqrt{2}$ factor to obtain an identical torque.

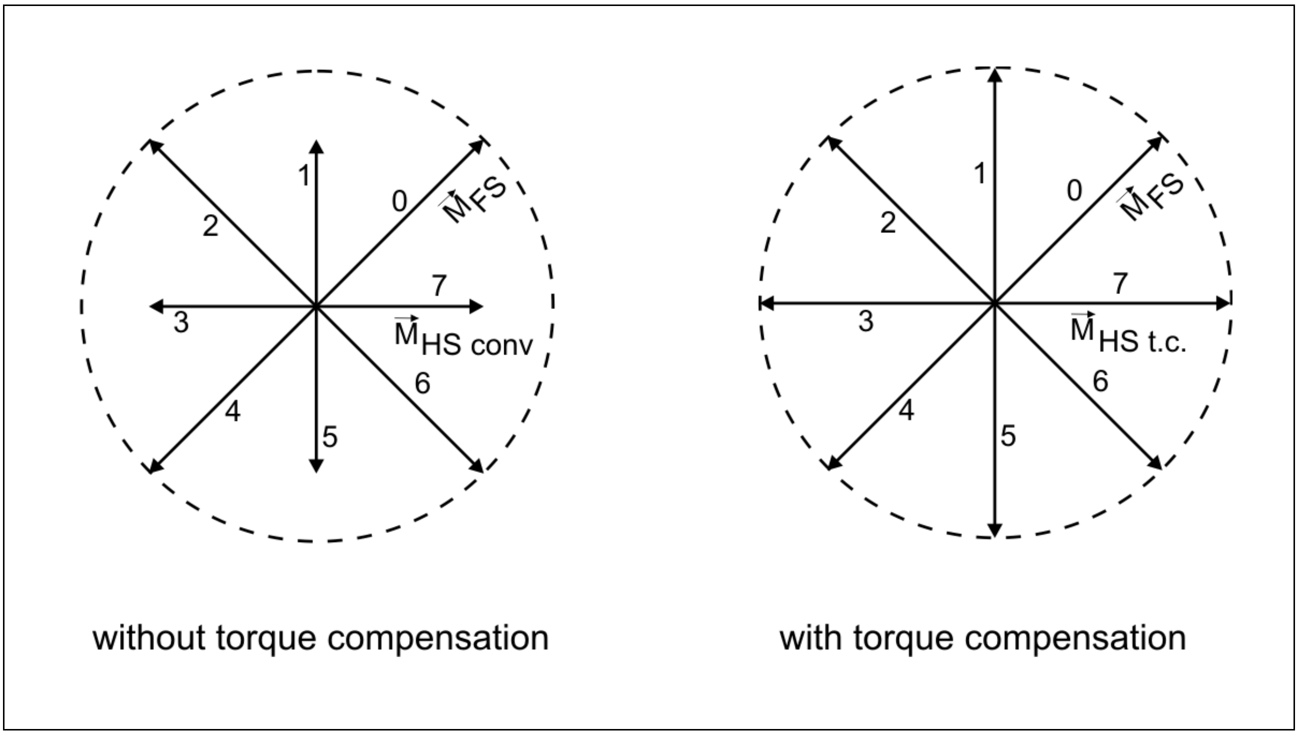


Fig. 6: Holding torques without/with torque compensation

- *All recent phytron power stages automatically perform the torque compensation.*

Micro Step

The step resolution of the controller can be increased electronically to up to 1/512 of a full step (depending on the selected module). A 200 step motor can, in theory, be commanded to one of 102,400 positions (equal to 0.0035° per micro step) per revolution.

Various advantages are obtained with the micro step mode:

- The torque undulation drops when the number of micro steps is increased.
- The achievable torque can increase up to 1/8 step, also a further increase of the resolution does not increase torque.
- Resonance and overshoot phenomena are greatly reduced; the motor operation is almost resonance-free.
- The motor noise also drops when the number of micro steps is increased.

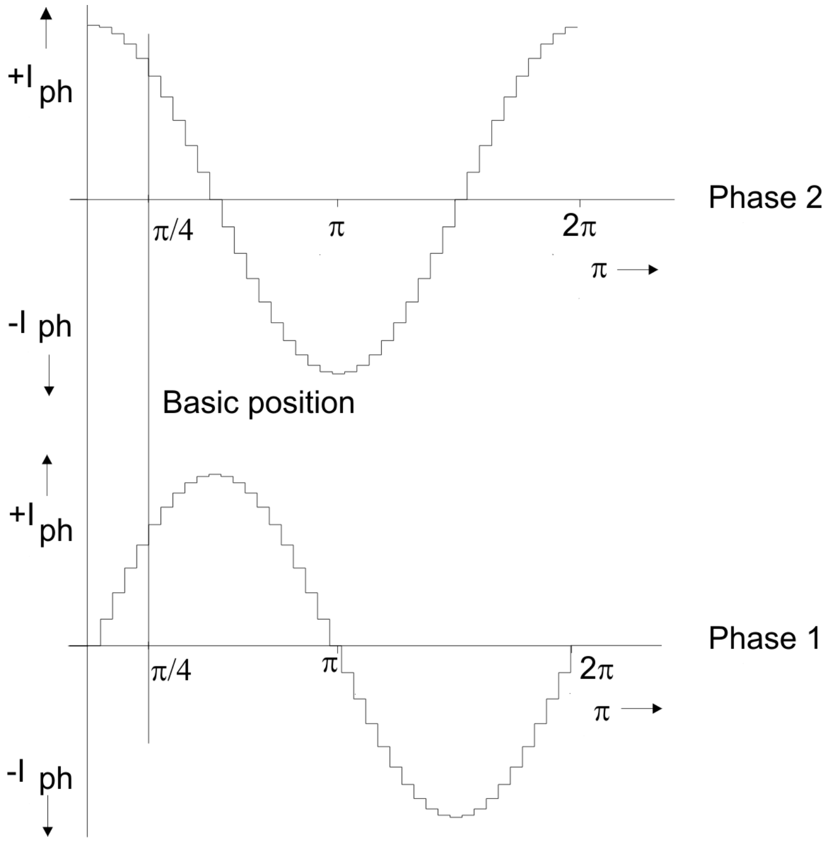


Fig. 7: Schematic profile of the phase currents with 1/10 micro step (of a full step)

i If using the highest micro step settings to perform accurate and absolute precision positioning use an attached encoder in order to achieve this. Then you can ensure the achievement of the target position or readjust if necessary. Even the slightest mechanical failure in the stepper motor can cause an incorrect micro step.

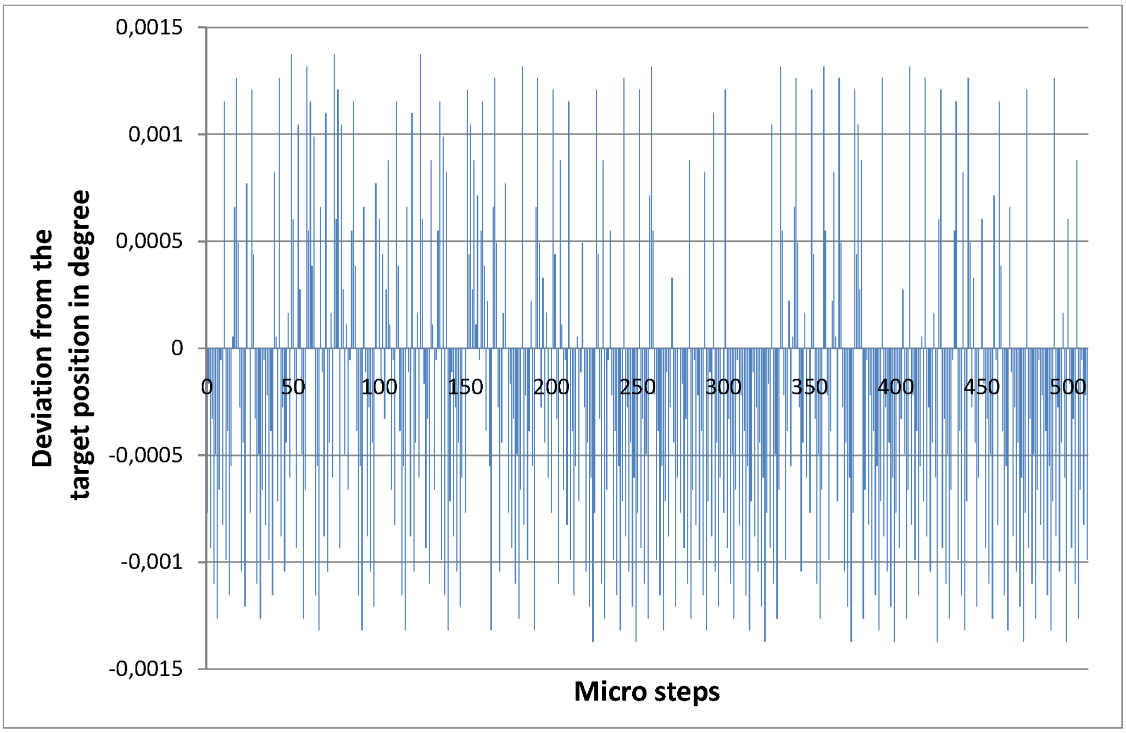


Fig. 8: Deviation from the target positioning in degree (for the APS01 power stage module)

4.4 Current Hold Time

After the last control pulse, the stop current is activated after a set time to minimize power consumption and motor heating. The time after the last control pulse until changing to the stop current is called Current Hold Time (t_{DELAY} / P43).

Phytron recommends specifying t_{DELAY} so that the motor's oscillations are decaying after the last motor step and positioning is more accurate. The higher current in this case reduces the decay - and incorrect positioning is avoided.

Automatic change from run to stop current:

After the stop current is applied, the ratio between both phase currents remains the same in the respective current feed pattern. Changing from run to stop current is achieved synchronously. This is necessary not to lose the current position. The phytron power stages lower the current automatically synchronous.
In the following figure, the next motor step follows every **rising** control pulse edge:

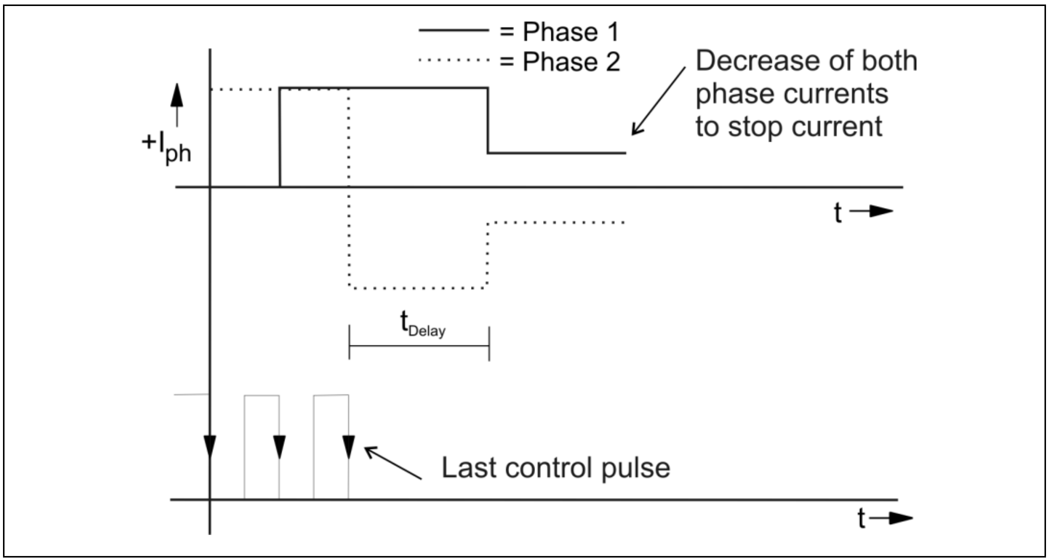


Fig. 9: Decrease to stop current after the last control pulse (full step)

Decreasing to stop current has the following advantages:

- Motor and power stage heating and power consumption is reduced.
- EMC is further improved due to smaller current values at a standstill.

The Current Hold Time t_{DELAY} after the last step of a motion job has the following advantages:

- The release time of the stepper motor at its target position will be accelerated. Therefore, the next motion job can be started quicker.
- Step loss, therefore incorrect positioning, by decaying effects on reaching a position is minimized.

5 Driving Functions of the Controller

The controller’s task is to position a stepper motor (incremental modes) or to travel continuous with specifiable frequencies (velocity control mode). In addition, many technology parameters as described above can be adapted in a way that the performance of the stepper motor and the customer´s drive system is optimised.

5.1 Relative Positioning

The mode “relative positioning” is used to move the stepper motor a defined distance and thus approach a specified position.

Command: e.g. 1.2+1000

*The 1.2 is the driving command in phy**LOGIC**TM to set a motion command for axis 2 on module card 1. +1000 means: drive 1000 steps in the selected step resolution in + direction*

5.2 Absolute Positioning

The “absolute positioning” mode is used to move the stepper motor to a defined position and thus approach a specified position.

Command: e.g. 1.2A1000

Again, the second axis on driving card 1 is selected. This time “A” stands for absolute positioning mode. In this case, 1000 stands for the absolute position 1000.

5.3 Velocity Control Mode

This operating mode specifies the frequency with which the pulses (steps) are output. When the frequency is changed, the pulses are output with the new frequency after an acceleration or deceleration phase. The output is carried out continuous until either stopping the job or a certain limit.

Command: e.g. 1.2L+

Again, axis 2 on driving card 1 is selected. This time L+ stands for drive in + direction with parameterized speed.

5.4 Search for Reference

The home position marks the point of reference of the drive system for the following motion jobs. You can determine the home position by, for example, installing a proximity switch and connecting it to one of the limit switch connectors on the driving cards. Alternatively, also a NOC (normally open contact) switch is possible.

Starting from the actual position Ⓟ there are different ways to move to the reference point REF C ⨁ (+ optional offset ◎). This search is defined by several parameters.

Parameter no.	Meaning
P04	Start/stop frequency The start/stop frequency is the maximum frequency to start or stop the motor without ramp. At higher frequencies, step losses or motor stop would be the result of a start or stop without ramp. The start/stop frequency depends on various factors: type of motor, load, mechanical system, power stage. The frequency is programmed in Hz.
P08	f_{max} MØP (mechanical zero point) Run frequency during initializing (referencing) Enter in Hz
P09	Ramp MØP Ramp during initializing, associated to parameter P08 For I1AM0x or I1EM0x the ramp can be adjusted in 4000-Hz/sec-steps
P10	f_{min} MØP Run frequency for leaving the limit switch / center switch Enter in Hz This frequency must be lower or equal to the start stop frequency to guarantee an accurate positioning.
P11 / P12	If parameters P11 / P12 are not 0 after driving to REF C ⨁ the controller will drive the parameterised offset to a defined point. ◯ Set the offset P11 (away from “LIMIT+” switch, towards “LIMIT–” switch) or P12 (away from “LIMIT–” switch towards “LIMIT+” switch) parameter.
P14	f_{max} Run frequency during program operation Enter in Hz (integer value)
P15	Ramp for run frequency (P14) Input in 4000-Hz/sec-steps (4000 to 500 000 Hz/sec)

Explanation of the reference run commands

R+	Reference run towards “LIMIT+” switch, optional offset*
R+C	Reference run towards “LIMIT+” switch, then towards center switch, then optional offset* (away from “LIMIT+“ switch towards „LIMIT–“ switch) P11
RC+	Reference run towards center switch (the direction depends on the center switch status’) then + offset (away from „LIMIT–“switch towards „„LIMIT+“ switch) P12
R+C^I	Reference run towards “LIMIT+” switch, center switch and then Encoder Index, then optional offset*
R-	Reference run towards “LIMIT–“ switch, optional offset*
R-C	Reference run towards “LIMIT–“ switch, then towards center switch, then optional offset (away from “LIMIT–“ switch towards “LIMIT+“ switch) P12
RC-	Reference run towards center switch (the direction depends on the center switch status’) then – offset* (away from “LIMIT+“ switch towards “LIMIT–“ switch) P11
R-C^I	Reference run towards “LIMIT–“ switch, center switch and then Encoder Index, then optional offset*

*) offset only if P11/P12 ≠ 0

The following diagrams are drawn for the I4XM01 module.

For the I1AMx or I1EMx the ramp always starts at 0.

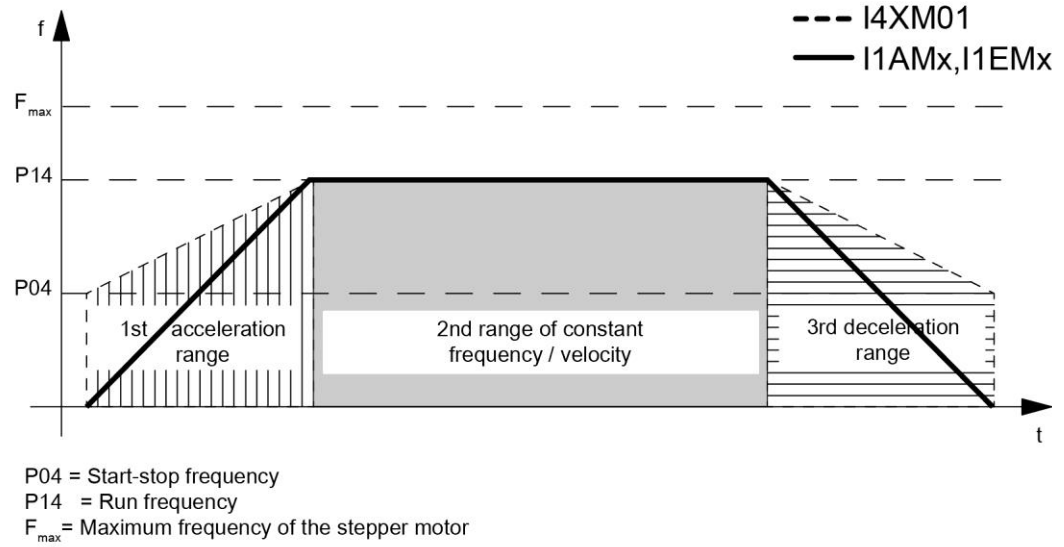


Fig. 10:Motion profile of the stepper motor controller

Driving on a *reference signal* to “center” (& offset) referring to command: “RC+”

Center switch 50% damped

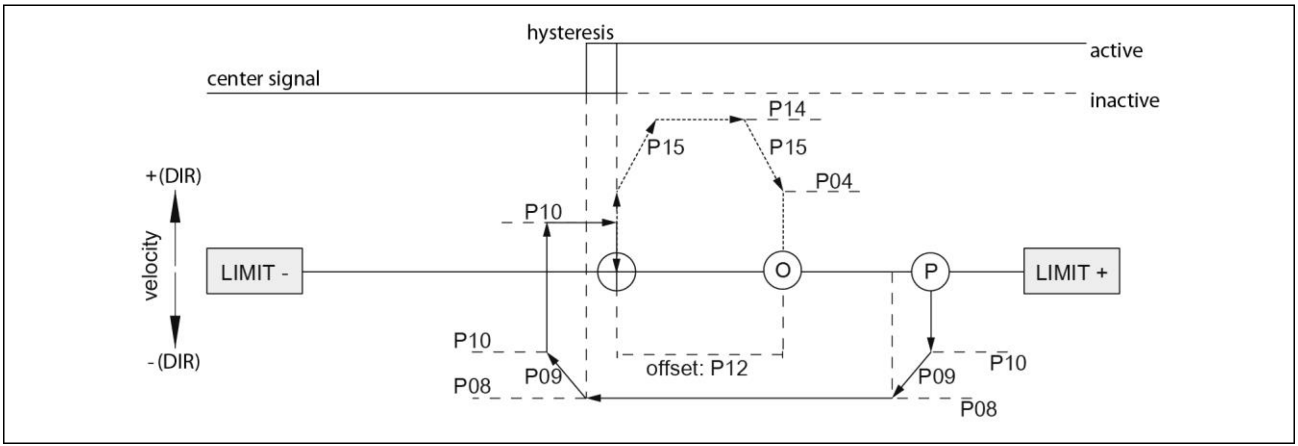


Fig. 11: Driving on a reference signal **starting from “signal active”** (“+ offset”: P12)

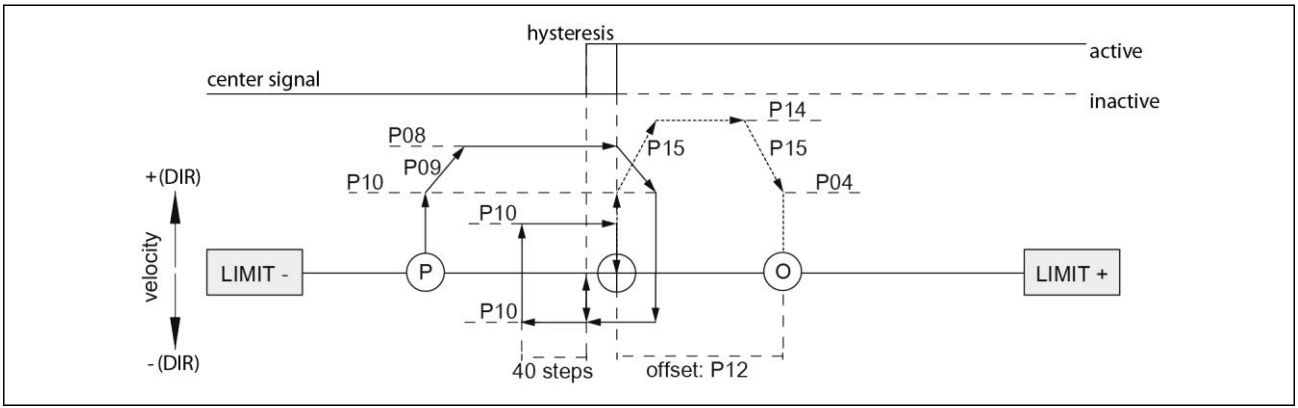


Fig. 12: Driving on a reference signal **starting from “signal inactive”** (“+offset”: P12)

Driving on a *reference signal* to "center" (& offset) referring to command "RC-"

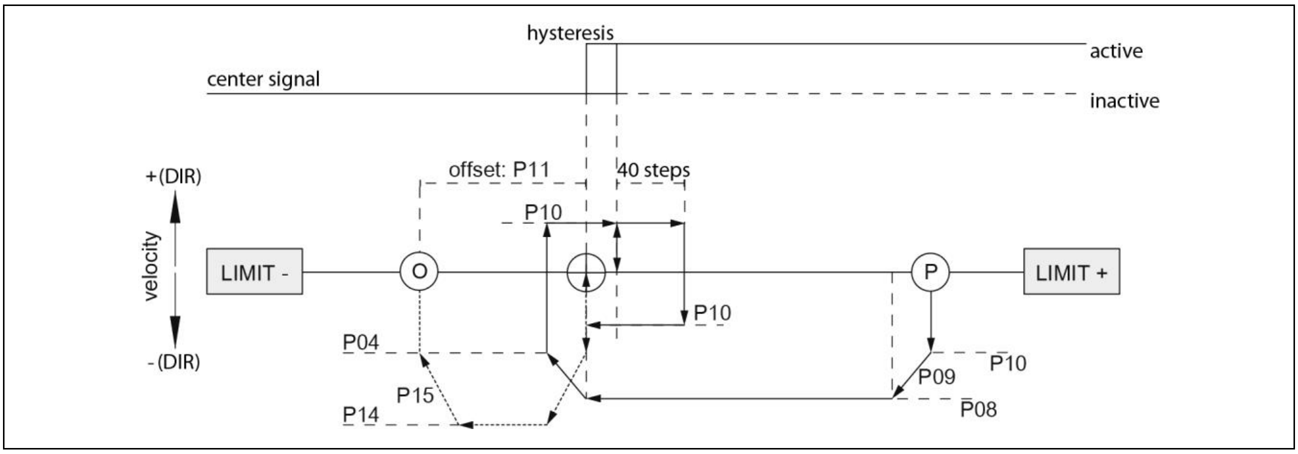


Fig. 13: Driving on a reference signal **starting from "signal active"** ("-offset": P11)

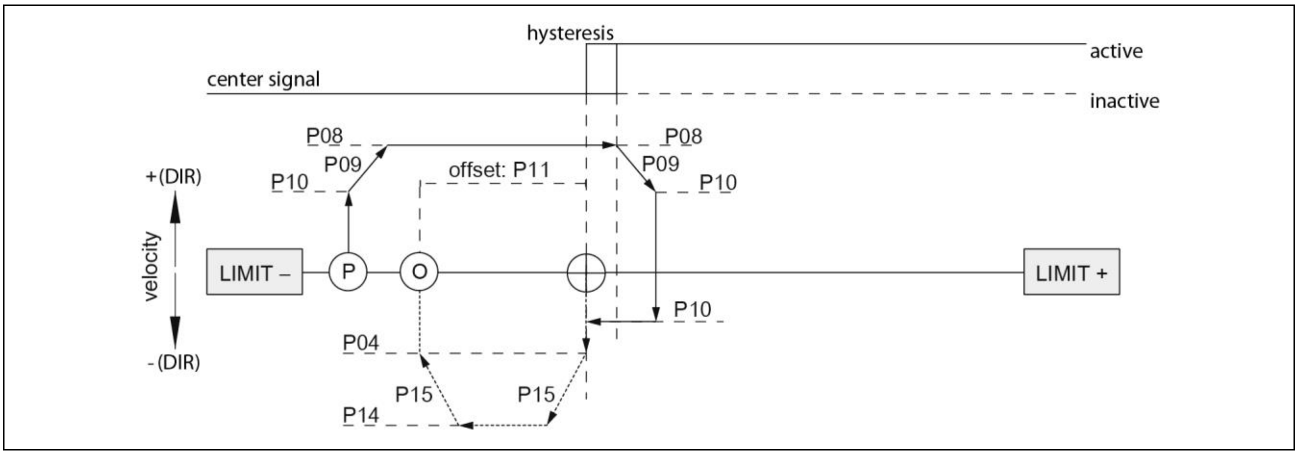


Fig. 14: Driving on a reference signal **starting from "signal inactive"** ("-offset": P11)

Driving on a *center switch* (& offset) referring to command "R+C"

Center switch selective damped

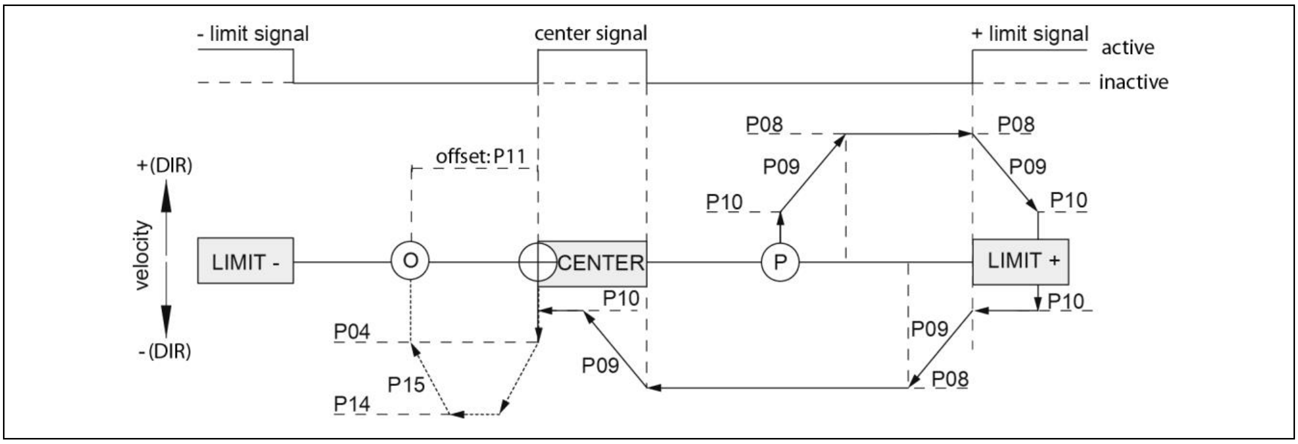


Fig. 15: Driving on a center switch **starting right to "center"** via "LIMIT+" switch ("- offset": P11)

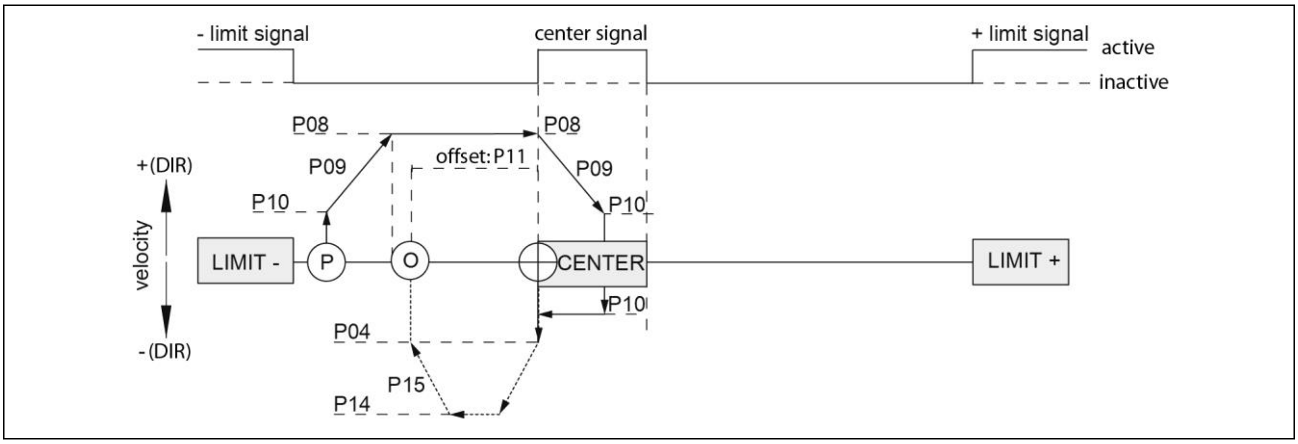


Fig. 16: Driving on a center switch **starting left to "center"** ("- offset": P11)

Driving on a *center switch* (& offset) referring to command “R-C”

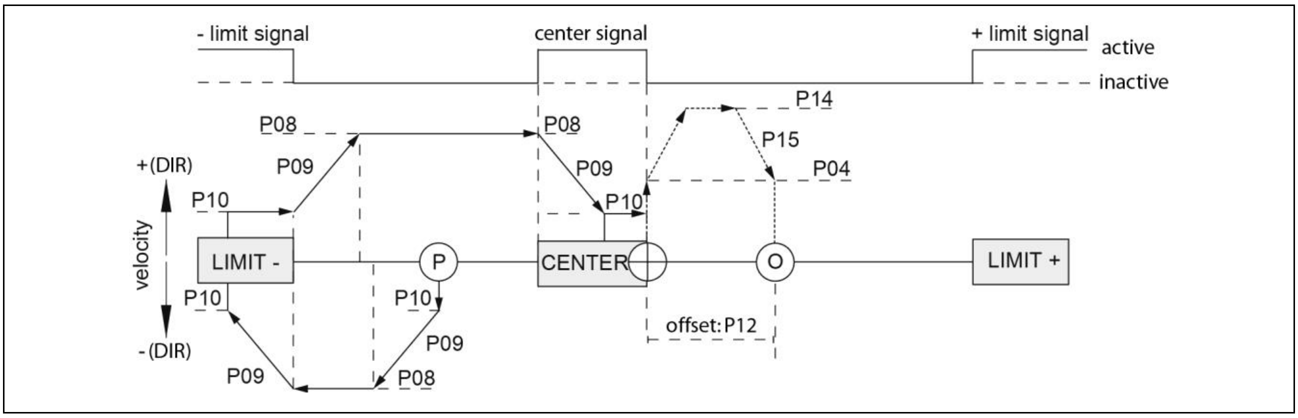


Fig. 17: Driving on a center switch **starting left to “center”** via “LIMIT–“ switch (“+ offset”: P12)

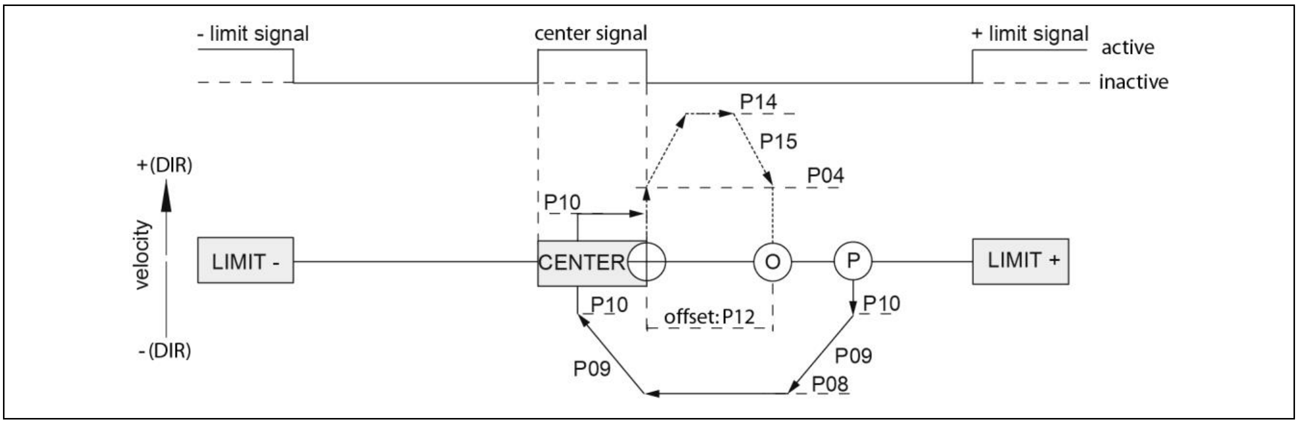
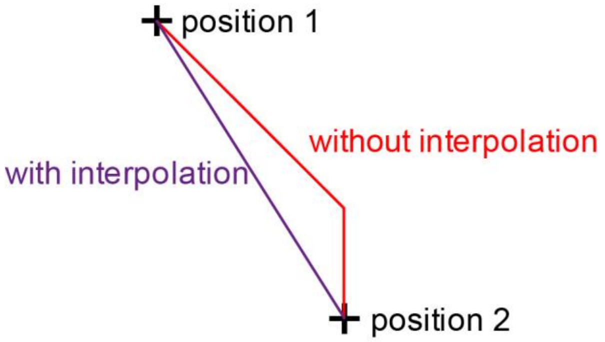


Fig. 18: Driving on a center switch **starting right to “center”** (“+ offset”: P12)

5.5 Linear Interpolation

Only with the modules I4XM01 or I2XM01

An interpolation function is necessary for displaying paths with more than one axis. The new position is automatically approached by then velocity adjustment of all participated axes on a straight path. The linear interpolation can handle all four axes.



Without interpolation, you must adjust the parameters for the velocity of both axes manually. Therefore, both axes start and finish the run simultaneously.

The linear interpolation ensures this automatically so that always position 2 is approached directly (linear connection).

Use the following *phy***LOGIC**™ commands for programming the linear interpolation:

	Linear interpolation
	Enter distance or position in P18 of the axis (i.e.1.1P18S5000 1.2P18S1000)
mIaw;bw;cw;dw	Start of the interpolation (for I4XM01 ONLY) m → module number a,b,c,d → number of the axis w=A → absolute running w=R → relative running Example: 1I1A;2R → Module 1, axis 1 absolute, axis 2 relative Response: <STX><ACK>:CS <ETX>(NUR PC)

5.6 Circular Interpolation

Only with the modules I4XM01 or I2XM01

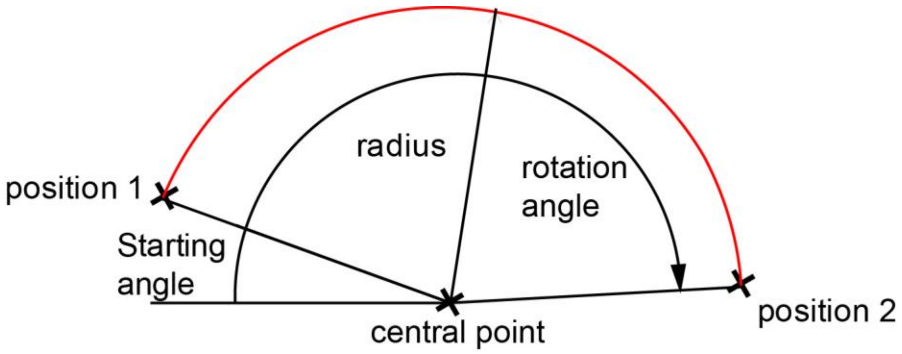
The circular interpolation is necessary for running multiple axes in a coordinated motion similar to the linear interpolation. Here, however, they are circular or elliptical paths. From the current position of the central point calculated with the radius and the starting angle with the radius a circular movement is performed. The circular movement stops at the indicated rotation angle.

The sign of the rotation angle defines the direction:

Rotation angle > 0 → Direction counter-clockwise

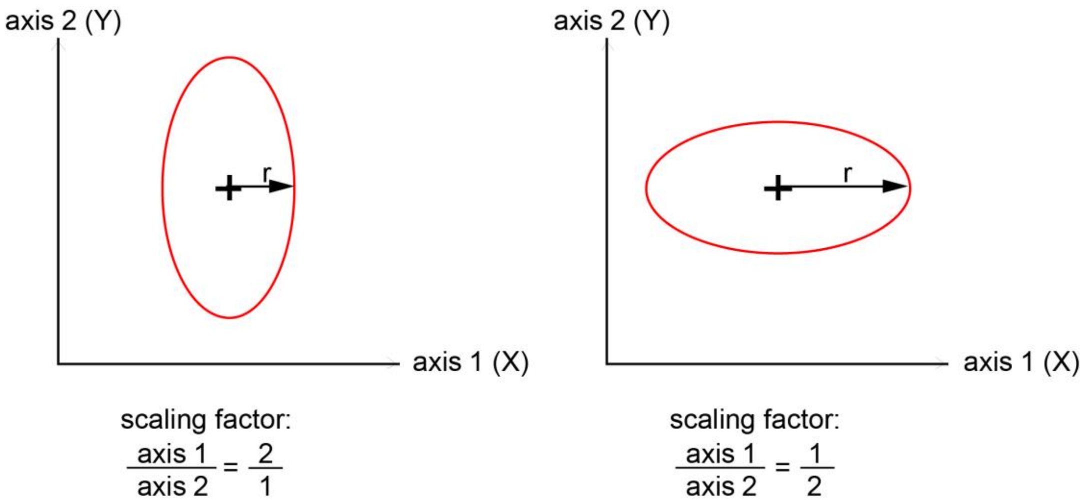
Rotation angle < 0 → Direction clockwise

The circular interpolation can handle with two of four axes.



For displaying ellipses, a different adjustment of the factor of both participated axes is necessary. The indicated radius always defines the dimension of axis 1 (X).

Example:



Use the following *phy***LOGIC**™ commands for programming the circular interpolation:

x**KR**n Set the radius n of the circular arc for the Indexer module x,
the unit and the factor of n are defined in P2 and P3 (see chap. 6)

x**KS**n Set the starting point n on the circular path for the Indexer module x in degree (°)
n =0 to 360°

x**KW**n Set the path (sector) n in degree (°) from the starting point for the Indexer module x
n =0 to 360° (CCW)
n =0 to -360° (CW)

Important: Write these 3 commands in **1** program line!

Example: 1KR100 1KS90 1KW180

x**KG**a;b Set the axis assignment of the Indexer card x ,

a= Master axis (1,2 or 3)

b=Slave axsis (1,2,3 or 4)

x**KT**a:b Set the divider of axis a and axis b of the Indexer module x (for ellipsis run)

a: divider for axis 1
b: divider for axis 2

6 List of Parameters

For operating a stepper motor controller several presetting as speed, acceleration ramps or waiting time is required. This presetting is called **Parameters**.

Default parameters are stored which can be used in several applications at delivery. You can read and edit these parameters with *phy***LOGIC**™ ToolBox.

Several counters are also contained in the list of parameters, which will be continuously actualized by the program. The counters can be read and some of them can be edited, too.

- For each axis, separate parameters have to be set. Insert a module and axis number to mark the axis in front of the parameter number.

  Example: m.aP15 is the acceleration ramp value for axis m.a.

- Parameters (e.g. speeds) may be modified several times within a program, too.
- Parameter values can be entered or read.
- P49 can only be read.
- P20 to P22 are counters. The program will actualize them during axis movement.
- P27 to P54 are special parameters for the *phy***MOTION**™.

No.	Meaning	Default
P01	Type of movement (free run, relative / absolute, reference run) 0 = Rotational movement (ignoring limit switches) 1 = Hardware limit switches are monitored for XY tables or other linear systems, 2 limit switches: Mechanical zero and limit direction – Limit direction + 2 = Software limit switches are monitored 3 = Hardware and software limit switches are monitored	0
P02	Measuring units of movement: only used for displaying 1 = step 2 = mm 3 = inch 4 = degree	1
P03	Conversion factor for the thread 1 step corresponds to ... If P03 = 1 (steps) the conversion factor is 1. Computing the conversion factor: $Conversion\,factor = \frac{Thread}{Number of\ steps\ per revolution}$ <u>Example</u>: 4 mm thread pitch 200-step motor = 400 steps/rev. in the half step mode $Conversion\,factor = \frac{4}{400} = 0.01$	1
P04	Start/stop frequency The start/stop frequency is the maximum frequency to start or stop the motor without ramp. At higher frequencies, step losses or motor stop would be the result of a start or stop without ramp. The start/stop frequency depends on various factors: type of motor, load, mechanical system, power stage. The frequency is programmed in Hz.	400
P05 **P06**	not used	

No.	Meaning	Default
P07	Emergency stop ramp Input for I1AM0x or I1EM0x: in 4000 Hz/s steps I4XM01: in 1 Hz/s steps	100 000
P08	f_{max} MØP (mechanical zero point) Run frequency during initializing (referencing) Enter in Hz (integer value) I1AM0x or I1EM0x: 40 000 maximum I4XM01: 4 000 000 maximum	4000
P09	Ramp MØP Ramp during initializing, associated to parameter P08 Input for I1AM0x or I1EM0x: in 4000 Hz/s steps I4XM01: in 1 Hz/s steps	4000
P10	f_{min} MØP Run frequency for leaving the limit switch range Enter in Hz	400
P11	MØP offset for limit switch direction + (away from “LIMIT+” switch, towards “LIMIT–” switch) Distance between reference point MØP and limit switch activation Unit: is defined in parameter P02 P11>=0	0
P12	MØP offset for limit switch direction – (away from “LIMIT–” switch, towards “LIMIT+” switch) Distance between reference point MØP and limit switch activation Unit: is defined in parameter P02 P12>=0	0
P13	Recovery time MØP Time lapse during initialization Enter in msec	20

No.	Meaning	Default
P14	f_{max} Run frequency during program operation Enter in Hz (integer value) I1AM0x or I1EM0x: 40 000 maximum I4XM01: 4 000 000 maximum	4000
P15	Ramp for run frequency (P14) Input for I1AM0x or I1EM0x: in 4000 Hz/s steps I4XM01: in 1 Hz/s steps	4000
P16	Recovery time position Time lapse after positioning Input in msec	20
P17	Boost (current is defined in P42) 0 = off 1 = on during motor run 2 = on during acceleration and deceleration ramp Remarks: The boost current is set in parameter P42 for internal power stages. You can select with parameter P17 in which situation the controller switches to boost current. P17 = 1 means, the boost current always is switched on during motor run. During motor standstill, the controller switches to stop current.	0
P18	Internally used for position specification	
P19	Deviation between P21 and P20	
P20	Distance counter This counts the pulses that are sent to the power stage. It is automatically set to 0 with reference travel in the reference point.	0

Positioning

No.	Meaning	Default
P21	Absolute counter Encoder, multi turn and for single turn. The value of P22 is extended to P21 by software. The encoder counters have a fixed resolution, e.g. 10 bit (for single-turn encoders: the resolution is bits per turn), then the read value repeats. A saw tooth profile of the numerical values is produced during a continuous motor running. This course is "straightened" by software. P20 and P21 will be scaled to the same value per revolution by P3 and P39 and are therefore directly comparable, see P36.	0
P22	Encoder counter Indicates the true absolute encoder position. If zero is set only for A/B encoders (after reset), the absolute encoders retain their value. Can be written to A/B encoders with command m.NP20=value.	0
P23	Software Limit Switch (Axial limitation pos. direction +) If the distance is reached, the run in + direction is aborted. 0 = no limitation	0
P24	Software Limit Switch (Axial limitation neg. direction –) If the distance is reached, the run in – direction is aborted. 0 = no limitation	0
P25	Compensation for play Indicates the distance, the target position in the selected direction is passed over and afterwards is started in reverse direction. 0 = no compensation for play	0

<table>
<tr><th>No.</th><th>Meaning</th><th>Default</th></tr>
<tr><td>P26</td><td>The data transfer rate is set by P26 (ONLY for SSI encoder), which read the encoder. The transfer rate is dependent on the length of the cable by which the encoder is connected to the device. The shorter the cable, the encoder can more quickly be read.

Data transfer rate 1 to 10 (= 100 to 1000 kHz)
1 = 100 kHz
2 = 200 kHz
3 = 300 kHz
4 = 400 kHz
5 = 500 kHz
6 = 600 kHz
7 = 700 kHz
8 = 800 kHz
9 = 900 kHz
10 = 1000 kHz</td><td>1</td></tr>
<tr><td>P27</td><td>Limit switch type
NCC: normally closed contact
NOC: normally open contact
<table>
<tr><th></th><th>LIMIT–</th><th>Center/Ref</th><th>LIMIT+</th></tr>
<tr><td>0</td><td>NCC</td><td>NCC</td><td>NCC</td></tr>
<tr><td>1</td><td>NCC</td><td>NCC</td><td>NOC</td></tr>
<tr><td>2</td><td>NOC</td><td>NCC</td><td>NCC</td></tr>
<tr><td>3</td><td>NOC</td><td>NCC</td><td>NOC</td></tr>
<tr><td>4</td><td>NCC</td><td>NOC</td><td>NCC</td></tr>
<tr><td>5</td><td>NCC</td><td>NOC</td><td>NOC</td></tr>
<tr><td>6</td><td>NOC</td><td>NOC</td><td>NCC</td></tr>
<tr><td>7</td><td>NOC</td><td>NOC</td><td>NOC</td></tr>
</table></td><td>0</td></tr>
<tr><td>P28</td><td>Axis options
0 = Power stage is deactivated after power on
1 = Power stage is activated after power on</td><td>0</td></tr>
<tr><td colspan="3">P29 not used</td></tr>
</table>

<table>
<tr><th>No.</th><th>Meaning</th><th>Default</th></tr>
<tr><td>P30</td><td>For I4XM01 only!

Frequency band setting

0 = manual
1 = automatic

<u>Remark</u>:
It is recommended to work with the automatic setting mode.
The controller selects the correct frequency band for the defined frequency and ramp.</td><td>1</td></tr>
<tr><td>P31</td><td>For I4XM01 only!

Frequency and ramp predivider (only if P30 = 0, manual)

This parameter changes the predivider that supplies the hardware (frequency generated) with a clock of 20 MHz derived.</td><td>3</td></tr>
<tr><td></td><td>
<table>
<tr><th>P31</th><th>Run frequency</th><th>resolution</th><th>predivider</th></tr>
<tr><td>0</td><td>1 Hz … 8 kHz</td><td>⅛ Hz</td><td>2440</td></tr>
<tr><td>1</td><td>1 Hz … 16 kHz</td><td>¼ Hz</td><td>1220</td></tr>
<tr><td>2</td><td>1 Hz … 32 kHz</td><td>½ Hz</td><td>609</td></tr>
<tr><td>3</td><td>1 Hz … 65 kHz</td><td>1 Hz</td><td>304</td></tr>
<tr><td>4</td><td>2 Hz … 130 kHz</td><td>2 Hz</td><td>152</td></tr>
<tr><td>5</td><td>4 Hz … 260 kHz</td><td>4 Hz</td><td>75</td></tr>
<tr><td>6</td><td>8 Hz … 520 kHz</td><td>8 Hz</td><td>37</td></tr>
<tr><td>7</td><td>16 Hz … 1 MHz</td><td>16 Hz</td><td>18</td></tr>
<tr><td>8</td><td>32 Hz … 2 MHz</td><td>32 Hz</td><td>9</td></tr>
<tr><td>9</td><td>64 Hz … 4 MHz</td><td>64 Hz</td><td>4</td></tr>
</table>
The parameter can be used for individual settings when automatic frequency band setting for the specific application is not appropriate.</td><td></td></tr>
</table>

No.	Meaning	Default
P32	Positioning ramp shape 0 = s-shape 1 = linear ramp Remark: The s-shape ramp can be modified with P33 parameter.	1
P33	Arc value setting for s-shape ramp Values: 1 to 32767 P33: low value → steep s-shape ramp P33: high value → flat s-shape ramp	1
P34	Encoder type 0 = no encoder 1 = incremental 5.0 V 2 = incremental 5.5 V 3 = serial interface SSI binary Code 5.0 V 4 = serial interface SSI binary Code 5.5 V 5 = serial interface SSI Gray Code 5.0 V 6 = serial interface SSI Gray Code 5.5 V 7 = EnDat 5 V 8 = EnDat 5.5 V 9 = resolver 10 = LVDT 4-wire 11 = LVDT 5/6-wire 12 = BiSS 5,0 V 13 = BiSS 24,0 V	0
P35	Encoder resolution for SSI and EnDat encoder Enter max. encoder resolution in Bit (max. 48 Bit) Special feature EnDat: if the parameter is set to zero, the controller uses the resolution, which is read from the connected instrument.	10

No.	Meaning	Default
P36	Encoder function The parameter determines whether P21 is used as a pure counter or whether its value is continuously compared with the value of counter P20. With SFI, if the deviation P20 to P21 is greater than the tolerance P37, the axes will stop and error message will be issued. 0 = counter 1 = counter+SFI	0
P37	Encoder tolerance for SFI Enter tolerance value for SFI evaluation Input: tolerance value for SFI-evaluation in the selected resolution (P3 * P20). If P21 is used for step failure indication the scale of the counter P20 * P3 must be equal to the scale of the counter P21 * P39 and P21 must be set to zero after initialization of the scaling (or can be set to the same value as P20). e.g. scaling to 360°/rev.: Motor 200 steps per revolution, 1/20 step, →P3 = 360 / 200 / 20 = 0.09, encoder 10 bit / rev. → P39 = 360 / 2^{10} = 0.3515625	0
P38	Encoder preferential direction of rotation 0 = + (positive) 1 = – (negative)	0
P39	Encoder conversion factor 1 increment corresponds to ... Computing the conversion factor: $$Conversion\,factor = \frac{Thread}{Encodersteps\,per\,revolution}$$	1
P40	Stop current in 0.01 $A_{r.m.s.}$ or in 0.1 $A_{r.m.s.}$ steps depending on the power stage see manual of the power stage	2
P41	Run current in 0.01 $A_{r.m.s.}$ or in 0.1 $A_{r.m.s.}$ steps depending on the power stage see manual of the power stage	6

No.	Meaning	Default
P42	Boost current in 0.01 A r.m.s. or in 0.1 A r.m.s. steps depending on the power stage see manual of the power stage	10
P43	Current delay time in msec	20
P44	For I4XM01 only! Origin of the Control pulses for the axis 0 = 1:1 (Input=Output) 1 = from X 2 = from Y 3 = from Z 4 = from U 5 = from external	0
P45	Step resolution and pref. direction of rotation The step resolution depends on the type of power stage: see the manual of the power stage P45 only applies to INTERNAL power stages or power stages connected via a bus. Preferred direction of rotation: for APS or LPS applies: Bit7=1: negative preferred direction of rotation Bit7=0: positive preferred direction of rotation Example for APS (5A) power stager: P45=3_{dec} (11_{bin}): ¼ step resolution and positive preferred direction of rotation P45=131_{dec} (10000011_{bin}): ¼ step resolution and negative preferred direction of rotation	3
P46	not used	
P47	not used	
P48	not used	
P49	Power stage temperature in 1/10 °C	(read only)

No.	Meaning	Default
P50	Divider for Control pulses only for I4XM01 Control pulses $_{Output}$=1/(n+1) * Control pulses $_{Input}$ 0 : 1/(0+1)=1 1: 1/(1+1)= 1/2 2: 1/(2+1) =1/3 3: 1/(3+1)=1/4 4: 1/(4+1)=1/5 5: 1/(5+1)=1/6	n=0
P51	Pulse width: (n+1)*100 ns only for I4XM01 n: 0….255 e.g. n=19: (19+1)*100 ns=2000 ns= 2µs -> F_{max}=1/(2*2 µs)=250 kHz	n=19
P52	Internally used for trigger position.	
P53	Power stage monitoring 0 = off 1 = on	1
P54	Motor temperature in 1/10 °C -999999: Temperature module not existent -9999: negative overflow or temperature lower -220 °C at PT100 9999: positive overflow or temperature higher +390 °C at PT100	-999999 (read only)
P55	Motor temperature **warning** in 1/10 °C If the motor warmed up to a defined temperature value, a warning occurs. We recommend operating the motor until it is cooled again.	0
P56	Motor temperature **shut-off** in 1/10 °C If the motor warmed up to a defined temperature value, the controller switches off and the power stage must be reset.	0
P57	Resolver voltage n=3…10 (Volt)	3

No.	Meaning	Default
P58	Resolver ratio (ratio of primary to secondary winding) 0=1/8 1=1/4 2=1/2 3=1 4=2	2
P59	Modulo step width Setting the steps for one motor revolution	0
P60	Modulo Encoder Setting for encoder for one motor revolution	0
P61	Modulo revolutions (steps) Counter for number of revolutions Can only be set to 0.	0

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