PD42-x-1243-IOLINK IO-Link™ Firmware Manual

Firmware Version V1.00 | Document Revision V1.01 • 2020-NOV-10

PD42-x-1243-IOLINK is a small easy-to-use mechatronic PANdrive™ IO-Link™ Actuator device. It combines a NEMA17 stepper motor with controller and driver electronics. The IO Link connection through standard 4-pin M12 connector offers full control over the NEMA17 stepper motor as well as provide a industry-standard IO Link communication protocol enabling control, configuration, and status monitoring.

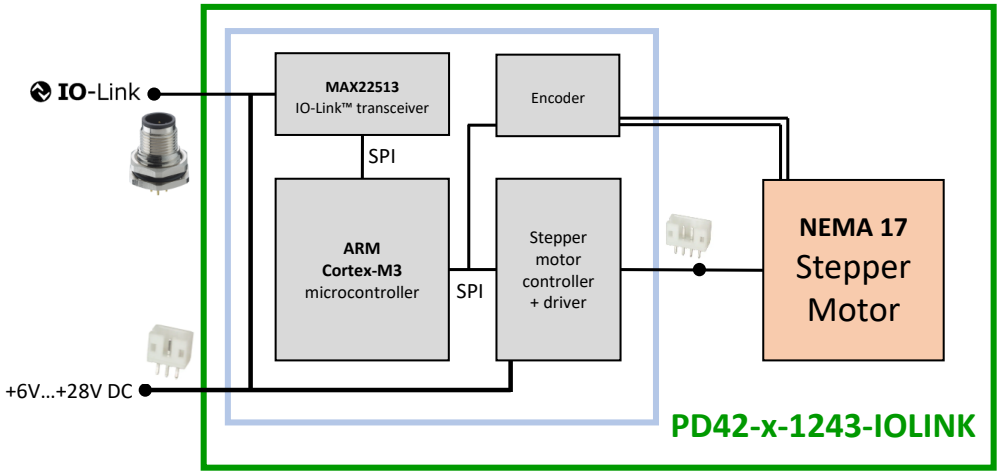
Features

- Stepper Motor **NEMA17** / 42mm
- **+6…+28V** DC Supply voltage
- Up to **1.2A RMS** motor current
- **IO-Link™** interface
- Integrated Motion Controller
- **PANdrive™** smart motor
- **StealthChop™** silent PWM mode
- **SpreadCycle™** current control
- **StallGuard2™** load detection
- **CoolStep™** autom. current scaling
- Integrated absolute position sensor

Applications

- Laboratory Automation
- Manufacturing
- Semiconductor Handling
- Robotics
- Factory Automation
- Test & Measurement

Simplified Block Diagram



Read entire documentation.

TRINAMIC
MOTION CONTROL
Now part of Maxim Integrated

Contents

1 Introduction

IO-Link® is a 3-wire industrial communications standard designed for linking sensors and actuators into control networks. The PD42-x-1243-IOLINK brings the power and capabilities of Trinamic motion controlled stepper motors into the IO-level of such networks.

The PD42-x-1243-IOLINK features

- a IO-Link COM3 Bitrate (230.4 kbit/s), and a
- MinCycleTime of 1.4 ms.

The Drive applies the Common Profile and the BLOB Transfer & Firmware Update Profile.
The IODD-file that is standardized by the IO-Link community, contains all required information to interface with the drive in a machine readable format. It can be downloaded from the Trinamic website: https://www.trinamic.com/products/drives/details/pd42-1-1243-iolink/.

For further information on IO-Link in general, have a look at Maxim's IO-Link Handbook [3].

The following pages give information on how to use the drive. Section 2 is about the Output Process Data that is used to control the motor position or velocity and about the Input Process Data witch gives feedback of the drive. In section 2 details on the settings of the drive and features that can be switched on and off, are given. When making first steps with the drive the Quick Start Guide section can be very helpful.

2 Process Data

2.1 Output Process Data

The output process data is used to control the motor.

2.1.1 Frame Structure

Figure 1: PD42-x-1243-IOLINK Output Process Data Bit Sizes and Bit Positions

2.1.2 Field Description

Target Position (Integer)	In position mode, the new target position to be moved to.
Target Velocity (Integer)	In velocity mode, the new target velocity to be moved with.
Control Word (Enumeration)	Sets the mode of operation.

Value	Operation
0	Off
1	Position Control
2	Velocity Control

2.2 Input Process Data

The input process data can be used to get feedback from the drive.

2.2.1 Frame Structure

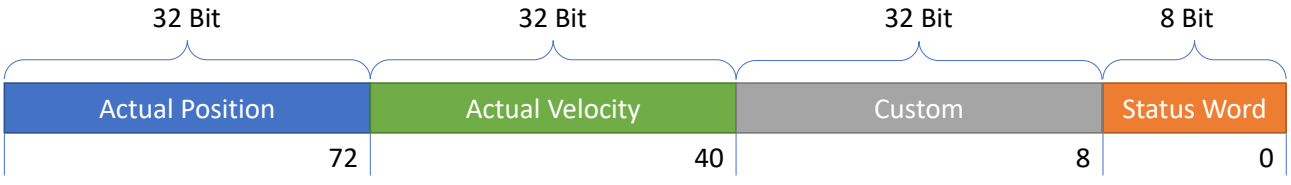


Figure 2: PD42-x-1243-IOLINK Input Process Data Bit Sizes and Bit Positions

2.2.2 Field Description

Actual Position (Integer)	Reflects the position of the motor.
Actual Velocity (Integer)	Reflects the velocity of the motor.
Custom (Integer)	Value of one of the monitoring parameters selected by parameter Custom Process Data Select
Status Word (Bit-Field)	A bit field used to check for positioning status, moving state and errors.

Bit	Flag	Description
0	Moving	Active during an ongoing moving action.
1	Position Reached	Signals, that the target position is reached. This bit is cleared if a new target position is given.
2	Velocity Reached	Signals, that the target velocity is reached. This bit is cleared if a new target position is given.
3	StallGuard Error	If the StallGuard is enabled, this flag is set when the motor was stopped due to a detected motor stall.
4	Following Error	If the following error detection is enabled (see section 5 for details), this flag is set when the motor was stopped due a detected following error.
5	Drive Error	This flag is the bit-wise logical OR-link of bit 1, 2, 3, and 4 of the Driver Chip Error Flags

3 ISDU Parameter

3.1 Parameter List

Parameter Name	Index	Data Type	Access	Default Value	DS
General Configuration					
Microstep Resolution	0x40	Uint8	rw	8	yes
Motor Steps per Revolution	0x41	Int32	rw	200	yes
Custom Process Data Select	0x42	Uint8	rw	0	yes
Current Limits					
Maximum Current	0x50	Int16	rw	128	yes
Standby Current	0x51	Int16	rw	8	yes
Encoder Parameter					
Initialize Position	0x61	Bool	rw	1	yes
Following Error Window	0x62	Int32	rw	0	yes
Set Encoder Position	0x63	Int32	wo	-	no
Profile Parameter					
Profile Start Velocity	0x70	Int32	rw	1	yes
Profile V1	0x71	Int32	rw	0	yes
Profile Velocity	0x72	Int32	rw	51200	yes
Profile Stop Velocity	0x73	Int32	rw	10	yes
Profile A1	0x74	Int32	rw	0	yes
Profile Acceleration	0x75	Int32	rw	51107	yes
Profile Deceleration	0x76	Int32	rw	51107	yes
Profile D1	0x77	Int32	rw	0	yes
Standby Delay	0x78	Int16	rw	0	yes
Ramp Wait Time	0x79	Int32	rw	0	yes
Power Down Ramp	0x7A	Int16	rw	7	yes
Smart Energy					
Smart Energy Current Minimum	0x80	Bool	rw	0	yes
Smart Energy Current Down Step	0x81	Uint8	rw	0	yes
Smart Energy Hysteresis	0x82	Int16	rw	0	yes
Smart Energy Current Up Step	0x83	Uint8	rw	0	yes
Smart Energy Hysteresis Start	0x84	Int16	rw	0	yes
Smart Energy Filter Enable	0x85	Bool	rw	0	yes
Smart Energy Threshold Speed	0x86	Int32	rw	15	yes

Parameter Name	Index	Data Type	Access	Default Value	DS
Chopper Parameter					
Fullstep Threshold Speed	0x90	Int32	rw	16777215	yes
High Speed Chopper Mode Enable	0x91	Bool	rw	0	yes
High Speed Fullstep Mode Enable	0x92	Bool	rw	0	yes
Stall Guard					
StallGuard2 Threshold	0xA0	Int16	rw	0	yes
Stop on Stall	0xA1	Int32	rw	0	yes
Stealth Chop					
PWM Threshold Speed	0xB0	Int32	rw	0	yes
PWM Gradient	0xB1	Int16	rw	0	yes
PWM Amplitude	0xB2	Int16	rw	0	yes
Monitoring					
Actual Load Value	0xC0	Int16	ro	-	no
PWM Scale Value	0xC1	Int16	ro	-	no
Motor Supply Voltage	0xC2	Int32	ro	-	no
Actual Current	0xC3	Int16	ro	-	no
Encoder Position	0xC4	Int32	ro	-	no
Homing					
Set Actual Position	0xD0	Int32	wo	-	no
Diagnosis					
Driver Chip Error Flags	0xE1	Uint8	ro	-	no
Drive Temperature	0xE2	Int32	ro	-	no

Table 1: Parameter List

3.2 Parameter Details

3.2.1 Microstep Resolution

Index	0x40
Value Range	0..8

Microstep resolutions per full step:

Value	Explanation
0	fullstep
1	halfstep
2	4 microsteps
3	8 microsteps
4	16 microsteps
5	32 microsteps
6	64 microsteps
7	128 microsteps
8	256 microsteps

3.2.2 Motor Steps per Revolution

Index	0x41
Value Range	0..65535

Number of full steps of the motor within one complete revolution. Please do not change! Changing this parameter is only needed if the drive is equipped with another motor.

3.2.3 Custom Process Data Select

Index	0x42
Value Range	0..4

Maps one of the monitoring parameters to the custom process data field.

Value	Parameter that is mapped to the custom process data field
0	Actual Load Value
1	PWM Scale Value
2	Motor Supply Voltage
3	Actual Current
4	Encoder Position

3.2.4 Maximum Current

Index	0x50
Value Range	0..255

Motor current used when the motor is running. The maximum value is 255 which means 100% of the current limit of the drive.

Value	Current Scaling factor (CS)	Resulting Percentage of the drives current limit
0..7	0	0%
8..15	1/32	3.125%
16..23	2/32	6.25%
…	…	…
248..255	32/32	100%

3.2.5 Standby Current

Index	0x51
Value Range	0..255

Motor current used when the motor is not running. The maximum value is 255 which means 100% of the maximum current of the module. This value should be as low as possible so that the motor can cool down when it is not moving.

3.2.6 Initialize Position

Index	0x61
Value Range	0..1

If enabled the actual position is initialized with the encoder position while the drive is booting.

3.2.7 Following Error Window

Index	0x62
Value Range	0..2147483647

Setting this parameter to a value different from 0 enables the encoder based position error detection. If the difference between the actual position and the encoder position is greater than the specified value, the motor is stopped and the "Following Error" Flag is set in the Status Word, see section 2.2.

3.2.8 Set Encoder Position

Index	0x63
Value Range	-2147483648...2147483647

With this parameter the encoder position can be set to zero or any other value. This is helpful in the context of homing via StallGuard. Beware that the internally calculated offset value is not stored permanently in the drive. See section 5 for more details on the encoder.

3.2.9 Profile Start Velocity

Index	0x70
Value Range	0..249999

Motor start velocity (in position mode only). Make sure this parameter is greater than Profile Stop Velocity.

3.2.10 Profile V1

Index	0x71
Value Range	0..1000000

First acceleration and decelaration phase target velocity (in position mode only). Setting this value greater than 0 enables the six point ramp (see section 6.3 for details)

3.2.11 Profile Velocity

Index	0x72
Value Range	0..7999774

The maximum speed used for positioning ramps.

3.2.12 Profile Stop Velocity

Index	0x73
Value Range	0..249999

Motor stop velocity (in position mode only).

3.2.13 Profile A1

Index	0x74
Value Range	0..7629278

First acceleration between Profile Start Velocity and Profile V1 (in position control only).

3.2.14 Profile Acceleration

Index	0x75
Value Range	0..7629278

Second acceleration between Profile V1 and Profile Velocity, in six point ramp mode, otherwise the liner ramp acceleration.

3.2.15 Profile Deceleration

Index	0x76
Value Range	0..7629278

First deceleration between Profile Velocity and Profile V1, in six point ramp mode, otherwise the liner ramp deceleration.

3.2.16 Profile D1

Index	0x77
Value Range	0..7629278

First deceleration between Profile V1 and Profile Stop Velocity (in position control only).

3.2.17 Standby Delay

Index	0x78
Value Range	0..400

Standstill period before the current will be ramped down to standby current. The value is given in a multiple of 10 ms, so the value 200 results in a delay of 2000 ms.

3.2.18 Ramp Wait Time

Index	0x79
Value Range	0..65535

Defines the waiting time after ramping down to zero velocity before next movement can start. Time range is 0 to 2 seconds. See diagram in figure 4.

3.2.19 Power Down Ramp

Index	0x7A
Value Range	0..15

Controls the number of clock cycles for motor power down after a motion as soon as the motor has stopped and the setting time has expired. The smooth transition avoids a motor jerk upon power down. A value of 0 means instant power down and a value of 15 makes the longest possible power down ramp.

3.2.20 Smart Energy Current Minimum

Index	0x80
Value Range	0..1

Also referenced as SEIMIN. Sets the lower motor current limit for CoolStep operation by scaling the CS value.

Value	Resulting lower motor current limit
0	$\frac{1}{2}$ of CS
1	$\frac{1}{4}$ of CS

3.2.21 Smart Energy Current Down Step

Index	0x81
Value Range	0..3

Sets the number of StallGuard2 readings above the upper threshold necessary for each current decrement of the motor current. Number of StallGuard2 measurements per decrement:

Value	measurements per decrement	remark
0	32	slow decrement
1	8	
2	2	
3	1	fast decrement

3.2.22 Smart Energy Hysteresis

Index	0x82
Value Range	0..15

Sets the distance between the lower and the upper threshold for StallGuard2 reading. Above the upper threshold the motor current becomes decreased.

3.2.23 Smart Energy Current Up Step

Index	0x83
Value Range	0..3

Sets the current increment step. The current becomes incremented for each measured StallGuard2 value below the lower threshold (see SmartEnergy hysteresis start).

Value	Current increment	remark
0	1	slow increment
1	2	
2	4	
3	8	fast increment / fast reaction to rising load

3.2.24 Smart Energy Hysteresis Start

Index	0x84
Value Range	0..15

The lower threshold for the StallGuard2 value (see SmartEnergy current up step).

3.2.25 Smart Energy Filter Enable

Index	0x85
Value Range	0..1

Enables the StallGuard2 filter for more precision of the measurement. It reduces the measurement frequency to one measurement per four fullsteps. In most cases it is expedient to set the filtered mode before using CoolStep. Keep it switched off for step loss detection.

3.2.26 Smart Energy Threshold Speed

Index	0x86
Value Range	0..2147483647

Above this speed CoolStep will be active.

3.2.27 Fullstep Threshold Speed

Index	0x90
Value Range	0..16777215

Speed at witch CoolStep is deactivated if High Speed Chopper Mode Enable is enabled. Also this is the speed at witch microstepping is switched to full step mode if High Speed Fullstep Mode Enable is enabled.

3.2.28 High Speed Chopper Mode Enable

Index	0x91
Value Range	0..1

Enables switching to other chopper mode when measured speed is exceeding the Fullstep Threshold Speed.

3.2.29 High Speed Fullstep Mode Enable

Index	0x92
Value Range	0..1

Enables switching to fullstep mode when measured speed is exceeding the Fullstep Threshold Speed.

3.2.30 StallGuard2 Threshold

Index	0xA0
Value Range	-63..63

This signed value controls StallGuard2 threshold level for stall output and sets the optimum measurement range for readout. A lower value gives a higher sensitivity. Zero is the starting value. A higher value makes StallGuard2 less sensitive and requires more torque to indicate a stall.

3.2.31 Stop on Stall

Index	0xA1
Value Range	0..2147483647

Below this speed motor will not be stopped. Above this speed motor will stop in case StallGuard2 load value reaches zero.

3.2.32 PWM Threshold Speed

Index	0xB0
Value Range	0..16777215

The StealthChop feature will be switched off when the actual velocity is higher than this value. It will be switched on when the actual velocity is below this value (and PWM Gradient is greater than zero).

3.2.33 PWM Gradient

Index	0xB1
Value Range	0..255

Velocity dependent gradient for PWM amplitude(StealthChop). Setting this value to 0 turns off StealthChop.

3.2.34 PWM Amplitude

Index	0xB2
Value Range	0..255

Maximum PWM amplitude when switching to StealthChop mode. Do not set too low. Values above 64 are recommended.

3.2.35 Actual Load Value

Index	0xC0
Value Range	0..1023

Readout of the actual load value used for stall detection (StallGuard2).

3.2.36 PWM Scale Value

Index	0xC1
Value Range	0..255

Actual PWM amplitude scaler, a value of 255 corresponds to maximum voltage. In voltage mode PWM, this value allows to detect a motor stall.

3.2.37 Motor Supply Voltage

Index	0xC2
Value Range	0..4095

Motor supply voltage given in a multiple of 10 mV. So a value of 2400 means 24 V.

3.2.38 Actual Current

Index	0xC3
Value Range	0..31

This status value provides the actual motor current setting as controlled by CoolStep. The value goes up to the CS value and down to the portion of CS as specified by SEIMIN (Smart Energy Current Minimum).

Value	Actual motor current scaling factor (CS)
0	1/32
1	2/32
…	…
31	32/32

Note that, if CoolStep is not enabled, this value only changes between standby- and maximum current depending on moving.

3.2.39 Encoder Position

Index	0xC4
Value Range	-2147483648..2147483647

The position determined by the internal encoder. See section 5 for further details on the Encoder.

3.2.40 Set Actual Position

Index	0xD0
Value Range	-2147483648..2147483647

With this parameter the actual position can be set to zero or any other value. This is helpful in the context of homing via StallGuard.

3.2.41 Driver Chip Error Flags

Index	0xE1
Value Range	0..255

Bit	Name	Description
0	StallGuard2 Status	1: Motor stall detected
1	Overtemperature	1: driver is shut down due to overtemperature
2	Overtemperature pre warning	1: overtemperature pre-warning threshold is exceeded
3	Short to ground A	1: short condition detected, driver currently shut down
4	Short to ground B	1: short condition detected, driver currently shut down
5	Open load A	1: no chopper event has happened during the last period with constant coil polarity
6	Open load B	1: no chopper event has happened during the last period with constant coil polarity
7	Stand still	1: motor halted

3.2.42 Drive Temperature

Index	0xE2
Value Range	-2147483648..2147483647

Measured temperature of the onboard temperature sensor.

4 Features

4.1 StallGuard™

StallGuard2 provides an accurate measurement of the load on the motor. It can be used for stall detection as well as other uses at loads below those which stall the motor, such as CoolStep loadadaptive current reduction. The StallGuard2 measurement value changes linearly over a wide range of load, velocity, and current settings.At maximum motor load, the value goes to zero or near to zero. This corresponds to a load angle of 90 ° between the magnetic field of the coils and magnets in the rotor. This also is the most energy-efficient point of operation for the motor.

For more details on StallGuard2 take a look at Application Note 002 [1].

4.2 SixPoint™ Ramp

The ramp generator allows motion based on target position or target velocity. It automatically calculates the optimum motion profile taking into account acceleration and velocity settings. The sixPoint offers faster machine operation compared to the classical linear acceleration ramps. The sixPoint ramp generator allows adapting the acceleration ramps to the torque curves of a stepper motor and uses two different acceleration settings each for the acceleration phase and for the deceleration phase.

5 Encoder

Please note that the PD42-x-1243-IOLINK is an open-loop system, hence the encoder value, obtained by reading monitoring parameter Encoder Position, can only be used to check if the motor has really reached its target position or really follows the position counter. The Hall-Effect based encoder has a resolution of 4096 counts and is scaled that the encoder counts match the position counts per rotation. For the scaling calculation the Microstep Resolution is also taken into account. The Encoder Position value is counting through multiple turns, but the number of turns will not be saved. So on every power-on the Encoder Position is initialized with the absolute position of the encoder.

With parameter Following Error Window, the encoder based step loss detection can be enabled. When enabled the motor is stopped as soon as the absolute difference between (scaled) encoder value and actual position is greater that the Following Error Window.

6 Quick Start Guide

6.1 Basic Move to Position

The factory default settings are chosen in a way that a positioning move only requires to set the process data. So setting

- the Control Word to "Position Control" and
- the Target Position to the desired target position, should move the motor.

Beware that per default the microstep resolution is set to 256, thus a full rotation requires 51200 counts.

6.2 Basic Rotating

Rotating the motor with a given speed is done by setting

- the Control Word to "Velocity Control" and
- the Target Velocity to the desired target velocity.

6.3 SixPoint™ Ramp Move

By default the six point ramp is disabled as the Profile V1 parameter is set to zero. In this mode a linear ramp is active like shown in the velocity over time diagram in figure 3.

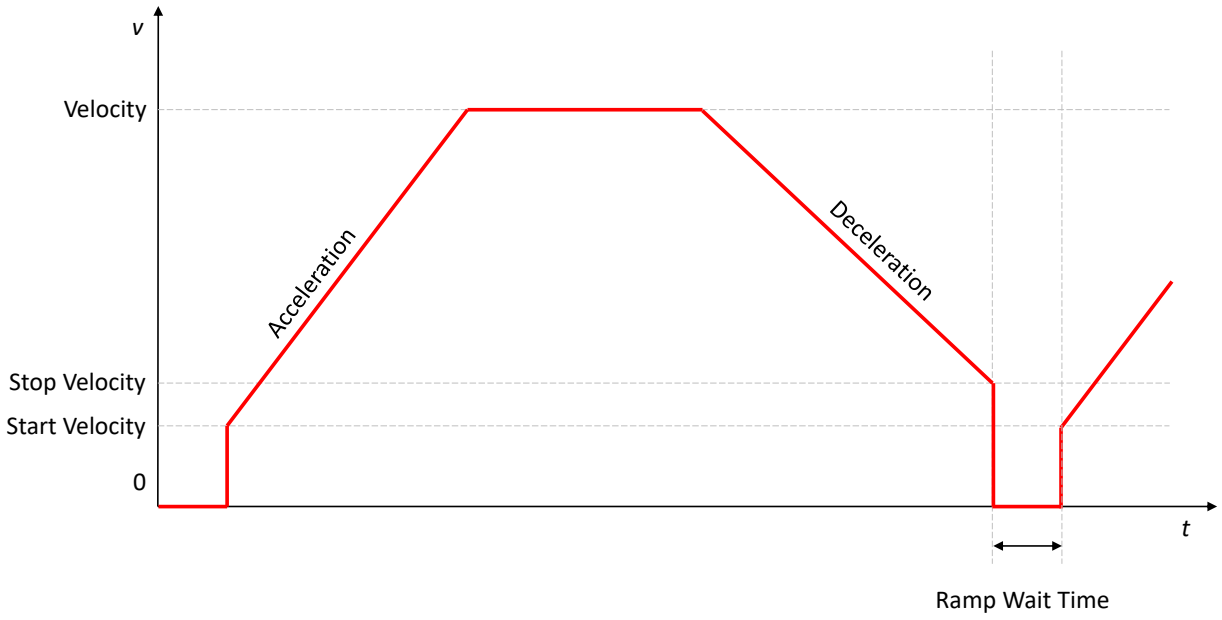


Figure 3: PD42-x-1243-IOLINK Linear ramp

To move to a position in six point ramp mode set

- Profile V1 to a value greater than 0 and
- set Profile A1 and Profile D1 to the desired value.

Optionally Profile Start Velocity and Profile Stop Velocity can be adapted. Now a position move can be done like described in section 6.1. With that the velocity over time characteristic will look like in diagram in figure 4.

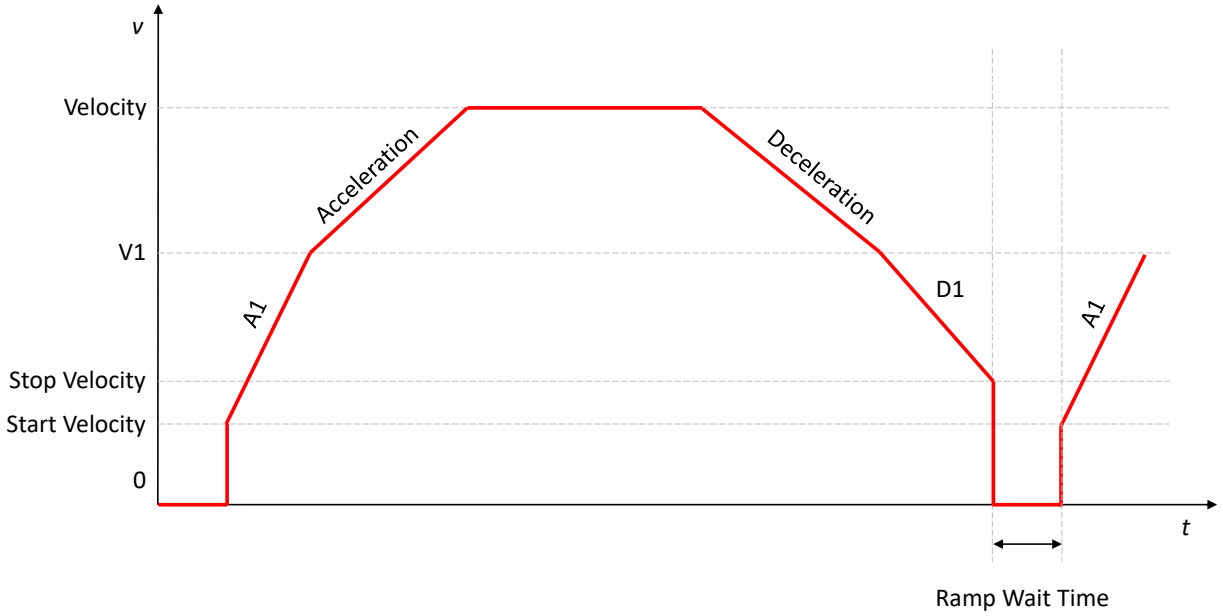


Figure 4: PD42-x-1243-IOLINK Six Point Ramp

6.4 StallGuard™ Stop on Stall Demo

Finding the right parameters for StallGuard2 is very much dependent on the load of the motor, so this example might only work without any load. Starting upon all parameters reset to their factory default state.

- Set the Maximum Current parameter to 32,
- set the StallGuard2 Threshold parameter to 1 and
- set the Stop on Stall parameter to 10000.

To demonstrate the Stop-on-Stall feature, start rotating the motor with a velocity of around 51200 ppm. Note that StallGuard2 will work in both position and velocity mode. When applying load to the motor the motor should stop at a certain load level, and the StallGuard Error flag will be set in the status word (see section 2.2). To rerun the motor, toggle the control word or write a different target position or target velocity, depending on the mode. Beware that this is only an example to get a feeling for the StallGuard2. A good value for StallGuard2 Threshold must be found for any individual combination of load and Maximum Current.

7 Acknowledgement

The firmware of the PD42-x-1243-IOLINK was developed in cooperation with TMG TE.

TMG Technologie Management Gruppe
Technologie und Engineering GmbH

Zur Gießerei 10

76227 Karlsruhe

Germany

Phone: +49 721 828060

Email: info@tmgte.de

Web: www.tmgte.com

8 References

[1] Trinamic. Application Note 002 - StallGuard™. https://www.trinamic.com/support/app-notes/.

[2] Trinamic. Application Note 009 - Tuning CoolStep™. https://www.trinamic.com/support/app-notes/.

[3] Maxim Integrated. IO-Link Handbook. https://www.maximintegrated.com/an6454

9 Figures Index

10 Tables Index

11 Supplemental Directives

11.1 Producer Information

11.2 Copyright

11.3 Trademark Designations and Symbols

Trademark designations and symbols used in this documentation indicate that a product or feature is owned and registered as trademark and/or patent either by TRINAMIC or by other manufacturers, whose products are used or referred to in combination with TRINAMIC's products and TRINAMIC's product documentation.

This IO-Link™ Firmware Manual is a non-commercial publication that seeks to provide concise scientific and technical user information to the target user. Thus, trademark designations and symbols are only entered in the Short Spec of this document that introduces the product at a quick glance. The trademark designation /symbol is also entered when the product or feature name occurs for the first time in the document. All trademarks and brand names used are property of their respective owners.

11.4 Target User

The documentation provided here, is for programmers and engineers only, who are equipped with the necessary skills and have been trained to work with this type of product.

The Target User knows how to responsibly make use of this product without causing harm to himself or others, and without causing damage to systems or devices, in which the user incorporates the product.

11.5 Disclaimer: Life Support Systems

TRINAMIC Motion Control GmbH & Co. KG does not authorize or warrant any of its products for use in life support systems, without the specific written consent of TRINAMIC Motion Control GmbH & Co. KG.

Life support systems are equipment intended to support or sustain life, and whose failure to perform, when properly used in accordance with instructions provided, can be reasonably expected to result in personal injury or death.

Information given in this document is believed to be accurate and reliable. However, no responsibility is assumed for the consequences of its use nor for any infringement of patents or other rights of third parties which may result from its use. Specifications are subject to change without notice.

11.6 Disclaimer: Intended Use

The data specified in this user manual is intended solely for the purpose of product description. No representations or warranties, either express or implied, of merchantability, fitness for a particular purpose

or of any other nature are made hereunder with respect to information/specification or the products to which information refers and no guarantee with respect to compliance to the intended use is given.

In particular, this also applies to the stated possible applications or areas of applications of the product. TRINAMIC products are not designed for and must not be used in connection with any applications where the failure of such products would reasonably be expected to result in significant personal injury or death (safety-Critical Applications) without TRINAMIC's specific written consent.

TRINAMIC products are not designed nor intended for use in military or aerospace applications or environments or in automotive applications unless specifically designated for such use by TRINAMIC. TRINAMIC conveys no patent, copyright, mask work right or other trade mark right to this product. TRINAMIC assumes no liability for any patent and/or other trade mark rights of a third party resulting from processing or handling of the product and/or any other use of the product.

11.7 Collateral Documents & Tools

This product documentation is related and/or associated with additional tool kits, firmware and other items, as provided on the product page at: www.trinamic.com.

12 Revision History

12.1 Firmware Revision

Version	Date	Author	Description
V1.00	2020-OCT-23	BP	Initial Version.

Table 2: Firmware Revision

12.2 Document Revision

Version	Date	Author	Description
V1.00	2020-OCT-23	BP	Initial version.
V1.01	2020-NOV-10	BP	Review.

Table 3: Document Revision