

# ***EPOS2***

## **Positioning Controller**

### **Documentation**

# **EPOS2 Firmware Specification Additional**

**Custom Specific Firmware**

**Sample Number: S12033**

**Application Number: 0129h**

maxon motor document #1577641-01

## 1 Table of contents

1	Table of contents.....	2
2	Table of figures .....	2
3	Table of tables.....	2
4	Introduction .....	3
4.1	How to use this guide.....	3
4.2	Additional documentations .....	4
4.3	Trademarks and Brand Names.....	4
5	Firmware .....	5
5.1	Torque Mode (customer-specific) .....	5
5.2	Torque Control Function .....	5
5.3	Analog Torque Feedback Functionality .....	6
5.4	Analog Input Functionalities .....	6
6	Object Dictionary.....	7
6.1	Application specific objects.....	7
6.1.1	Target Torque .....	7
6.1.2	Torque Actual Value .....	7
6.1.3	Torque Control Function .....	8
6.1.4	Analog Torque Feedback.....	9
6.2	Changed Objects .....	10
6.2.1	Configuration of Analog Inputs .....	10
6.2.2	Analog Input Functionalities Execution Mask .....	10
6.2.3	Mode of Operation .....	11
6.2.4	Supported Drive Modes .....	11
6.3	Overview of application specific Object changes.....	12
7	Firmware Version History.....	13
7.1	Firmware Version Overview .....	13
7.2	Software Version 2123h.....	13
7.3	Software Version 2123h AN0129h AV0100h.....	13

## 2 Table of figures

Figure 1:	EPOS2 50/5 photo .....	3
Figure 2:	EPOS documentation hierarchy.....	3
Figure 3:	Overview Torque Mode (customer-specific) .....	5
Figure 4:	Torque Controller – Block Diagram .....	5
Figure 5:	Analog Torque Feedback – Block Diagram .....	6
Figure 6:	Analog Input Functionality EPOS2 50/5 customer-specific .....	6

## 3 Table of tables

Table 1:	Sources of additional Information.....	4
Table 2:	Brand Names and Trademarks Owners .....	4
Table 3:	Analog Inputs - Configuration.....	10
Table 4:	Analog Input Functionality Execution Mask - Structure .....	10
Table 5:	Modes of Operation.....	11
Table 6:	Supported Drive Modes – Bits .....	12
Table 7:	Overview of new and changed objects .....	12
Table 8:	Firmware Versions Overview .....	13

## 4 Introduction

This documentation "EPOS2 Firmware Specification Additional" provides the Firmware Extensions due to Application Number 0129h of the EPOS2 positioning controller. This description should be used in addition to the documentation "Firmware Specification" Edition February 2012.



**Figure 1: EPOS2 50/5 photo**

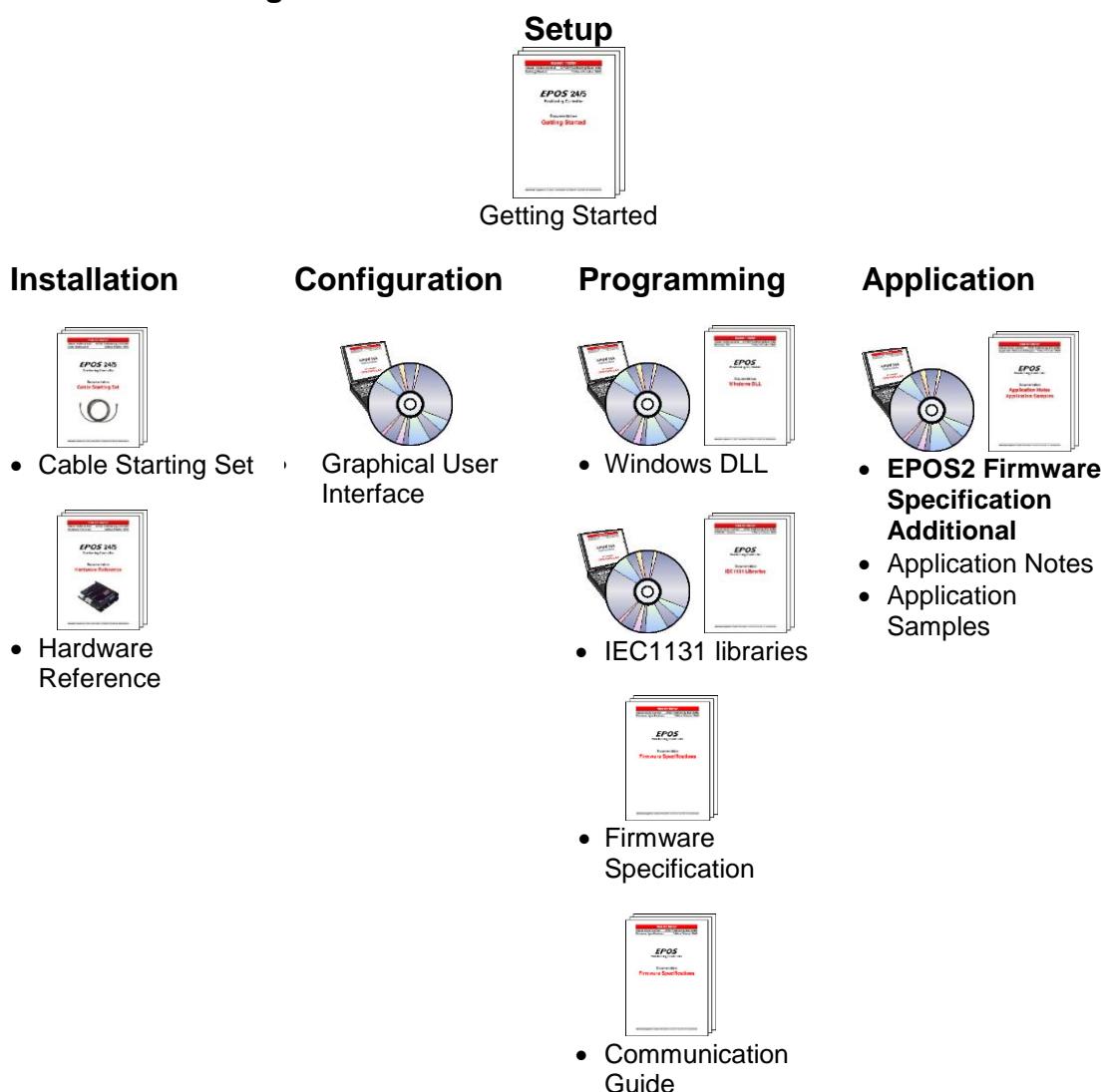
The maxon motor EPOS2 are small-sized full digital smart motion controllers. Due to the flexible and high efficient power stage the EPOS2 drives brushed DC motors with digital encoder as well as brushless EC motors with digital Hall sensors and encoder.

The sinusoidal current commutation by space vector control offers to drive brushless EC motors with minimal torque ripple and low noise. The integrated position-, velocity- and current control functionality allows sophisticated positioning applications. It is specially designed being commanded and controlled as a slave node in the CANopen® network. In addition the unit can

be operated through any RS-232 or USB communication port.

Additional documentations and standard software to the EPOS2 positioning controller may also be found on the internet in <http://www.maxonmotor.com> category <Service & Downloads>.

### 4.1 How to use this guide



**Figure 2: EPOS2 documentation hierarchy**

## 4.2 Additional documentations

For further details and additional information, please refer to below listed sources:

#	Reference	Link
[1]	CiA DS-301 Communication Profile for Industrial Systems	<a href="http://www.can-cia.org">www.can-cia.org</a>
[2]	CiA DSP-402 Device Profile for Drives and Motion Control	<a href="http://www.can-cia.org">www.can-cia.org</a>
[3]	Konrad Etschberger: Controller Area Network (ISBN3-446-21776-2)	
[4]	maxon motor: EPOS2 50/5 Getting Started	EPOS CD-ROM or <a href="http://www.maxonmotor.com">www.maxonmotor.com</a>
[5]	maxon motor: EPOS2 Firmware Specification Edition February 2012	EPOS CD-ROM or <a href="http://www.maxonmotor.com">www.maxonmotor.com</a>
[6]	maxon motor: EPOS2 50/5 Hardware Reference	EPOS CD-ROM or <a href="http://www.maxonmotor.com">www.maxonmotor.com</a>

**Table 1: Sources of additional Information**

## 4.3 Trademarks and Brand Names

For easier legibility, registered brand names are listed below and will not be further tagged with their respective trademark. It must be understood that the brands (the below list is not necessarily concluding) are protected by copyright and/or other intellectual property rights even if their legal trademarks are omitted in the later course of this document

Brand Name	Trademark Owner
CANopen® CiA®	© CiA CAN in Automation e.V, DE-Nuremberg

**Table 2: Brand Names and Trademarks Owners**

## 5 Firmware

The custom specific firmware for application number 0129h (Epos\_2122h\_6322h\_0129h\_XXXXh) is based on the standard EPOS2 Firmware (Epos\_2123h\_6322h\_0000h\_0000h).

In addition to the standard EPOS2 features a special mode of operation, the torque mode, is implemented.

### 5.1 Torque Mode (customer-specific)

The customer specific Torque Mode uses the torque feedback functionality to measure the actual torque using one of the Analog Inputs. The torque control functionality has the target torque and the torque actual value as input and the current desired value as output to the current control functionality. All the Torque Mode functions will be processed with a cycle time of 1ms.

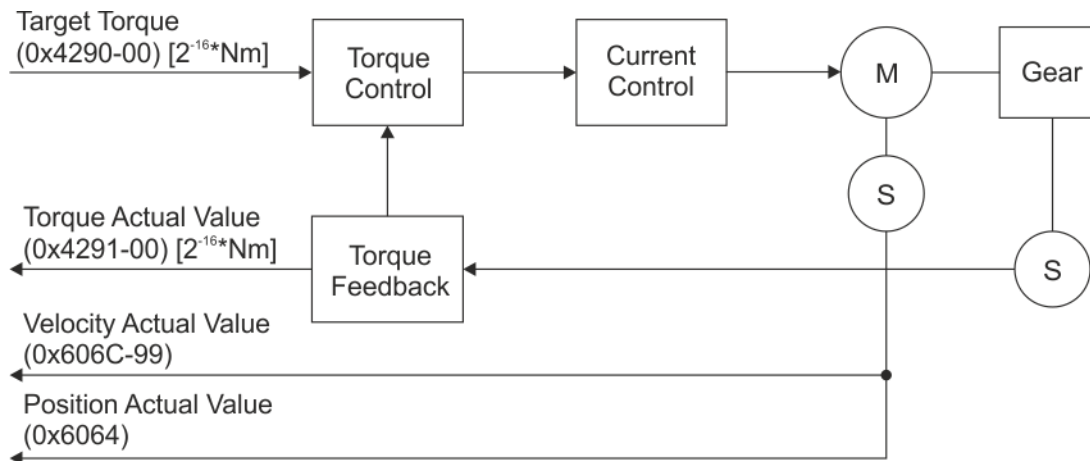


Figure 3: Overview Torque Mode (customer-specific)

### 5.2 Torque Control Function

The torque controller is a standard PDT1 controller with an additional feed-forward path.

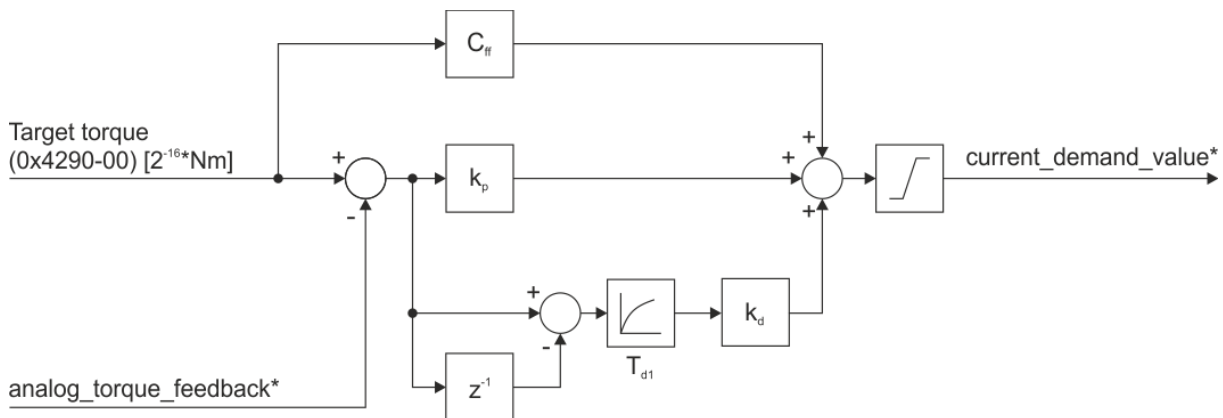


Figure 4: Torque Controller – Block Diagram

The transfer function of the PDT1 controller part can be used for analytical calculations:

$$C_{torque}(s) = k_p + \frac{k_d \cdot s}{1 + T_{d1} \cdot s} \quad T_{d1} = \frac{k_d}{16 \cdot k_p}$$

$k_p$ : ➔ Torque Controller P-Gain

$k_d$ : ➔ Torque Controller D-Gain

$C_{ff}$ : ➔ Torque Feedforward Scaling Constant

### 5.3 Analog Torque Feedback Functionality

The torque feedback functionality uses one of the analog input signals to convert the voltage signal from an external torque / force sensor to the torque feedback signal.

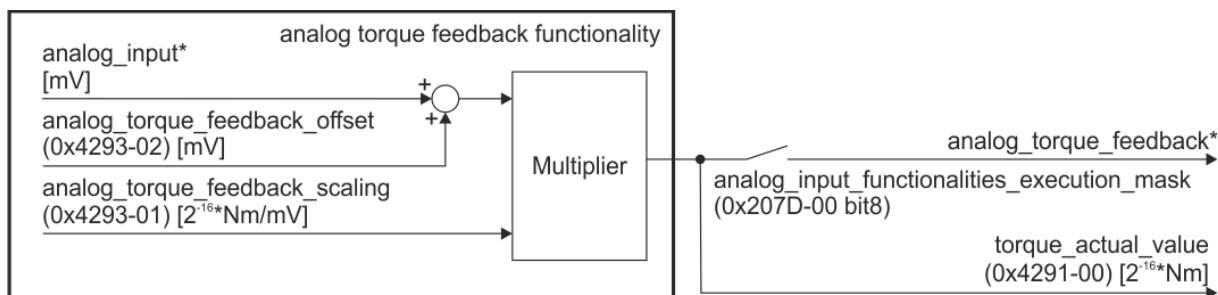


Figure 5: Analog Torque Feedback – Block Diagram

### 5.4 Analog Input Functionalities

In contrast to the standard EPOS2 50/5 firmware there are additional functionalities and different default values for the configuration of the analog inputs:

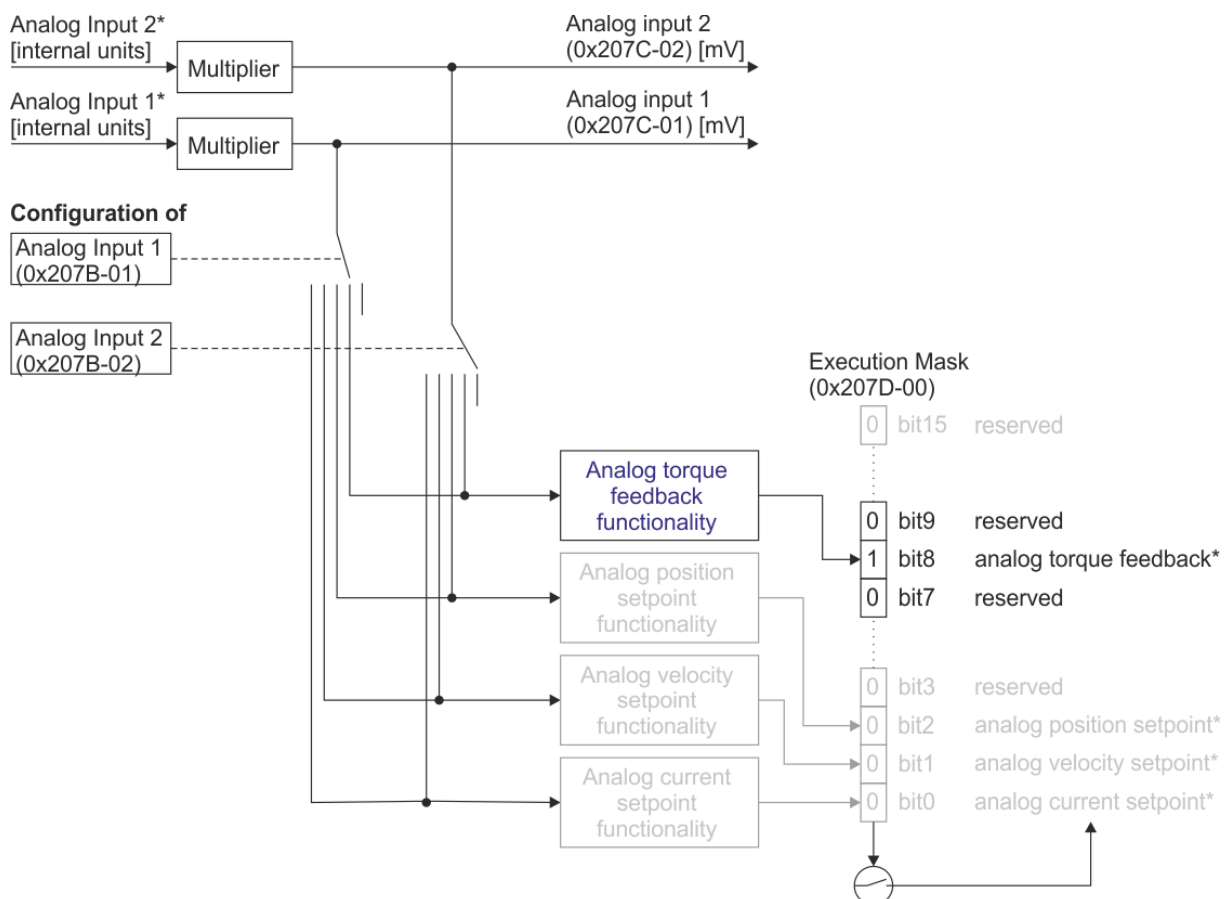


Figure 6: Analog Input Functionality EPOS2 50/5 customer-specific

## 6 Object Dictionary

### 6.1 Application specific objects

#### 6.1.1 Target Torque

##### Description

Desired torque of the torque controller [ $2^{-16} \cdot \text{Nm}$ ].

Name	Target Torque	
Index	0x4290	
Subindex	0x00	
Type	INTEGER32	
Access	RW	
Default Value	0	
Value range	-6'553'600	6'553'600 (100.0 Nm)
PDO mappable	Yes	

#### 6.1.2 Torque Actual Value

##### Description

Actual torque measured by the analogue torque feedback functionality [ $2^{-16} \cdot \text{Nm}$ ].

Name	Torque Actual Value	
Index	0x4291	
Subindex	0x00	
Type	INTEGER32	
Access	RO	
Default Value	0	
Value range	-	-
PDO mappable	Yes	

### 6.1.3 Torque Control Function

#### Description

Torque control is done by a PD-controller with feed forward

Name	Torque Control Parameter Set
Index	0x4292
Number of entries	3

#### Description

Represents the proportional gain of the torque controller [ $2^{-16} \cdot \text{A/Nm}$ ].

Name	Torque Controller P-Gain	
Index	0x4292	
Subindex	0x01	
Type	INTEGER32	
Access	RW	
Default Value	65'536 (1.0 A/Nm)	
Value range	0	65'536'000 (1000.0 A/Nm)
PDO mappable	No	

#### Description

Represents the differential gain of the torque controller [ $2^{-16} \cdot \text{A} \cdot \text{ms/Nm}$ ].

Name	Torque Controller D-Gain	
Index	0x4292	
Subindex	0x02	
Type	INTEGER32	
Access	RW	
Default Value	65'536 (0.001 As/Nm)	
Value range	0	2'147'483'647 (32.768 As/Nm)
PDO mappable	No	

#### Description

Represents the torque feed forward factor of the torque controller [ $2^{-16} \cdot \text{mA/Nm}$ ].

Name	Torque Feedforward Scaling Constant	
Index	0x4292	
Subindex	0x02	
Type	INTEGER32	
Access	RW	
Default Value	0	
Value range	0	32'768'000 (500.0 mA/Nm)
PDO mappable	No	



### 6.1.4 Analog Torque Feedback

Name	Analog Torque Feedback Configuration
Index	0x4293
Number of entries	2

#### Description

Represents the scaling factor for analog torque feedback functionality in  $[2^{-16} \cdot \text{Nm/mV}]$

Name	Analog Torque Feedback Scaling	
Index	0x4293	
Subindex	0x01	
Type	INTEGER32	
Access	RW	
Default Value	32'768 (0.5 Nm/mV)	
Value range	-3'276'800	3'276'800 (50.0 Nm/mV)
PDO mappable	No	

#### Description

Represents the scaling factor for analog torque feedback functionality in [mV]

Name	Analog Torque Feedback Offset	
Index	0x4293	
Subindex	0x02	
Type	INTEGER16	
Access	RW	
Default Value	0	
Value range	-10'000	10'000 (10V)
PDO mappable	No	

## 6.2 Changed Objects

### 6.2.1 Configuration of Analog Inputs

#### Description

Configures which functionality will be assigned to analog input 1 and 2.

Name	Configuration of Analog Inputs
Index	0x207B
Number of entries	2

Name	Configuration of Analog Input 1	Configuration of Analog Input 2
Index	0x207D	
Subindex	0x01...0x02	
Type	UNSIGNED16	
Access	RW	
Default Value	Configuration of Analog Input 1: 7 Configuration of Analog Input 2: 14	
Value range	0	15

Value	Functionality	Description
15...8	general purpose	General purpose A...H
7	torque feedback	An analog input is used in «Torque Mode (customer specific) » to process the torque feedback
6...3	reserved	
2	position setpoint	An analog input is used in «Position Mode» to command the position control function.
1	velocity setpoint	An analog input is used in «Velocity Mode» to command the velocity control function.
0	current setpoint	An analog input is used in «Current Mode» to command the current control function.

**Table 3: Analog Inputs - Configuration**

### 6.2.2 Analog Input Functionalities Execution Mask

#### Description

With the execution mask the analog input functionalities can be kept off from execution

Name	Analog Input Functionalities Execution Mask
Index	0x207D
Subindex	0x00
Type	UNSIGNED16
Access	RW
Default Value	0x0080
Value range	-

Bit 15...8	Bit 7	Bit 6..3	Bit 2	Bit 1	Bit 0
reserved	torque feedback	reserved	position setpoint	velocity setpoint	current setpoint

**Table 4: Analog Input Functionality Execution Mask - Structure**

### 6.2.3 Mode of Operation

#### Description

The parameter mode of operation switches the actually chosen operating mode.

Name	Modes of Operation	
Index	0x6060	
Subindex	0x00	
Type	INTEGER8	
Access	RW	
Default Value	-32	
Value range	→ Table 5	-

Operation Mode	Description
7	Interpolated Position Mode
6	Homing Mode
3	Profile Velocity Mode
1	Profile Position Mode
-1	Position Mode
-2	Velocity Mode
-3	Current Mode
-4	Diagnostic Mode
-5	Master Encoder Mode
-6	Step/Direction Mode
-32	Torque Mode (customer specific)

**Table 5: Modes of Operation**

### 6.2.4 Supported Drive Modes

#### Description

Provides an overview of the implemented operating modes in the device.

Name	Supported Drive Modes	
Index	0x6502	
Subindex	0x00	
Type	UNSIGNED32	
Access	CONST	
Default Value	0x103F0065	
Value range	-	-

maxon motor		
EPOS2 Positioning Controller		EPOS2 Firmware Specification Additional
Bit		Description
31...29	0	reserved
28	1	Torque Mode (customer specific)
27...22	0	reserved
21	1	Maxon Step/Direction Mode
20	1	Maxon Master Encoder Mode
19	1	Maxon Diagnostic Mode
18	1	Maxon Current Mode
17	1	Maxon Velocity Mode
16	1	Maxon Position Mode
15...7	0	reserved
6	1	Interpolated Position Mode
5	1	Homing Mode
4	0	reserved
3	0	(Torque Mode, not implemented)
2	1	Profile Velocity Mode
1	0	(Velocity Mode, not implemented)
0	1	Profile position Mode

**Table 6: Supported Drive Modes – Bits**

### 6.3 Overview of application specific Object changes

The following objects are new or the default values were modified for this custom firmware:

Index, Subindex		Name	standard default	AN0129 default
0x207B	0x01	→ Configuration of Analog Input 1	15	7
0x207D	0x00	→ Analog Input Functionalities Execution Mask	0	0x0080
0x4290	0x00	→ Target Torque	-	-
0x4291	0x00	→ Torque Actual Value	-	-
0x4292	0x01	→ Torque Controller P-Gain	-	65'536
0x4292	0x02	→ Torque Controller D-Gain	-	65'536
0x4292	0x03	→ Torque Feedforward Scaling Constant	-	0
0x4293	0x01	→ Analog Torque Feedback Scaling	-	32'768
0x4293	0x02	→ Analog Torque Feedback Offset	-	0
0x6060	0x00	→ Mode of Operation	1	-32
0x6510	0x00	→ Supported Drive Modes	-	-

**Table 7: Overview of new and changed objects**

## 7 Firmware Version History

### 7.1 Firmware Version Overview

Date	Software Version	Hardware Version	Application Number	Application Version	Description
15.12.2011	2123h	6322h, ...	0000h	0000h	Base for AN0129h
20.08.2012	2123h	6322h	0129h	0100h	New application

**Table 8: Firmware Versions Overview**

### 7.2 Software Version 2123h

Please refer to documentation “Firmware Specification” [\[5\]](#).

### 7.3 Software Version 2123h AN0129h AV0100h

#### Binary Files

Hardware	Firmware Filename
EPOS2 50/5	Epos_2123h_6322h_0129h_0100h.bin

#### Description New Features

New Feature	Description
Application	Implementation customized Torque Mode functionality