EPOS2

Positioning Controller

Application Note
"Interpolation Position Mode"

Edition December 2008

EPOS2 50/5, EPOS Module 36/2
Firmware version 2101h or higher

Introduction

The EPOS2 positioning controller is a digital positioning system suitable for DC and EC (brushless) motors with incremental encoders in a modular package. The performance range of these compact positioning controllers ranges from a few watts up to 250 watts.

A variety of operating modes allows all kinds of drive and automation systems to be flexibly assembled using positioning, speed and current regulation. The built-in CANopen interface allows networking to multiple axis drives and online commanding by CAN bus master units.

For fast communication with several EPOS devices, use the CANopen protocol. The individual devices of a network are commanded by a CANopen master.

Objectives

This application note explains the functionality of interpolation position mode. Interpolated position mode is used to control multiple coordinated axes or a single axis with the need for time-interpolation of setpoint data. In interpolated position mode, the trajectory is calculated by the CANopen master and passed to the controller's interpolated position buffer as a set of points. The controller reads the points from the buffer and performs linear or cubic interpolation between them.

References and Required Tool

The latest editions of maxon motor documents and tools are freely available at http://www.maxonmotor.com category «Service & Downloads».

Document	**Suitable order number for EPOS Positioning Controller**
EPOS2 Communication Guide EPOS2 Firmware Specification	347717, 360665
CANopen documentation	Specifications 'DS-301 Version 4.02' and 'DSP-402 Version 2.0' CiA (CAN in Automation e. V.) http://www.can-cia.org

Tool	
EPOS Studio Version 1.30 or higher	347717, 360665

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2.1 Explanations to the Interpolated Position Mode

Introductory analogy:
In a company a department manager must convert the department goals into clear tasks for his coworkers. It is to be considered that often the individual tasks stand to each other in close interdependency. Thus each department manager is glad, if he has capable coworkers, who are able to solve their tasks already on basis on substantial data. For the quality of such a solution it is in particular important that it:

1. is factually correct, i.e. it does not have to be controlled again,
2. is finished in time and
3. was reached efficiently.

The functionality ***Interpolated Position Mode*** values up the positioning controller *EPOS2* to such a "capable coworker" in a superordinated drive system. This thesis is described in the following text.

In a drive system normally several axes must be moved after the guidelines of a central controller. This can take place in the way that each local axis controller receives the next target position in real time – i.e. in time and at the same time to each sampling instance –. This strategy has the advantage that the local controller need only little intelligence. However, the central controller must compute target positions for every sampling interval and has to communicate the data to every local controller in real time.

In the sense of the introductory analogy it would be favorable, if only few, but substantial points of the driving profiles have to be regarded. Besides it would be desirable, if the corresponding data have to be communicated to the local controller not necessarily at the same time but only in time. Both goals can be reached by *interpolation* and *data buffering*.

The central controller decides first which points of the local trajectories are substantial for a synchronized total movement. Then each relevant point of the local trajectories is supplemented with the corresponding velocity and time, i.e. triples of the kind (**p**osition, **v**elocity, **t**ime = PVT) are formed. These triples are then transferred to the associated axis controllers in time. Each local controller possesses a buffer in order to take up these data. The buffer of the *EPOS2* covers 64 locations for triples. The transfer of data to the *EPOS2* is in time, if always the buffer contains at least 1 and at the most 64 new triples.

The local position regulation works at the *EPOS2* with a sampling rate of 1 kHz. I.e., there are 1000 target positions per second necessary in real time. These target positions are computed in the *EPOS2* by means of interpolation. Each triple forms a base point with the abscissa *time* and the two ordinates *position* and *velocity*. Two triples therefore deliver two abscissas and four corresponding ordinates, so that an interpolation polynomial of third order can be computed unambiguously between the two base points. This computation as well as the evaluation of the polynomial in the local sampling clock takes place on basis of simple arithmetic and is efficiently carried out by the *EPOS2*.

The endpoint of the polynomial [n] forms the starting point of the polynomial [n+1] Therefore it is sufficient to indicate only the relative time in a data triple, i.e. the length of the time interval. Concretely with the *EPOS2* the time distance of two base points can be selected between 1ms and 255ms. This interval length can be adapted by the central controller to realize the desired total movement.

With the goal that all controllers in the drive system refer to the same time base, the central controller initiates periodically a time check. This time synchronization takes place with the *EPOS2* via the *SYNC* time stamp mechanism.

Finally, the interpolated position mode can be qualified as follows: The resulting smooth driving profiles as well as the close temporal synchronization allow it in a drive system, to superpose several high-dynamic single movements to a precise total movement.

2.2 General Description

The Interpolated Position Mode descript in the CiA specification DSP402 V3.0 is a general case. The objects are well specified for a linear interpolation (PT). The interpolation type can also be extended by manufacturer specific algorithms (selectable by „Interpolation submode selection“, object 0x60C0).

2.3 Spline Interpolation

For the Interpolated Position Mode the interpolation type is a cubic spline interpolation. The higher-level trajectory planer sends a set of interpolation points by PVT reference point. Each PVT reference point contains the position, velocity, and time information of a profile segment end point. The trajectory generator of the drive performs a third order interpolation between the actual and the next reference point.

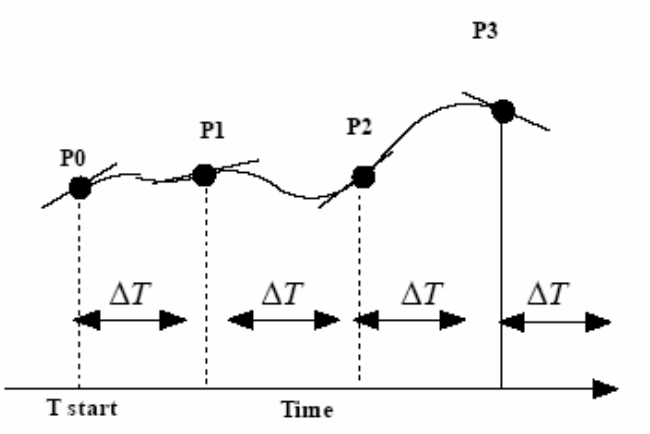


Figure 1: Interpolated Position PVT Principle

The interpolation parameters **a, b, c,** and **d** can be calculated for each segment from the two successive PVT reference points:

$$d = P[t_0] = P[n]$$

$$c = V[t_0] = V[n]$$

$$b = T^{-2}[n] * (3 * (P[n] - P[n-1]) + T[n] * (V[n] + 2 * V[n-1]))$$

$$a = T^{-3}[n] * (2 * (P[n] - P[n-1]) + T[n] * (V[n] + V[n-1]))$$

The interpolated values for the position, the velocity, and the acceleration will be calculated as follows:

$$P(t) = a * (t - t_0)^3 + b * (t - t_0)^2 + c * (t - t_0) + d$$

$$V(t) = 3a * (t - t_0)^2 + 2b * (t - t_0) + c$$

$$A(t) = 6a * (t - t_0) + 2b$$

t_0: time of interpolation segment end (→ in this calculation t_0 is greater then **t**!)

It is not mandatory that the time intervals are identical.

2.4 SYNC-Time stamp mechanism

The SYNC-Time stamp mechanism can be used to synchronize the motion clock of the drive with a master clock in the network.

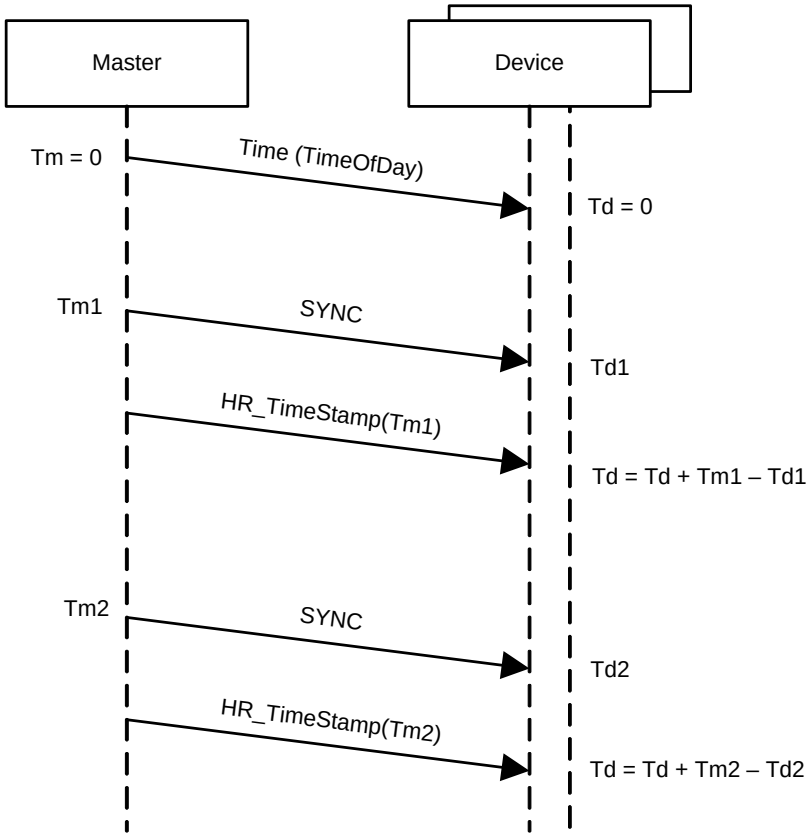


Figure 2: Clock synchronization

The synchronization method is similar to IEEE 1588 and uses the CANopen DSP301 SYNC Service (COB-Id 0x80) and the *High Resolution Time Stamp* Object (0x1013).

The SYNC Frame will be transmitted periodically by the SYNC master and the exact transmitting time (Tm1) should be stored in the master by latching an internal 1us timer. The reception time (Td1) of the SYNC message will be stored by latching the device internal motion clock timer. As following up the measured transmitting time (Tm1) will be send to the drive with the High Resolution Time Stamp. The device adjusts then its internal motion clock time in relation to the time latched in the last SYNC.

By sending a CANopen DSP301 TIME Service (default COB-Id 0x100 or defined by Object 0x1012) the device internal motion clock timer can be reset to zero.

3 IPM Implementation by Maxon

The Interpolated Position Mode is implemented in the EPOS2 as an additional operational mode (operation mode 7 as specified in DSP 402 V3.0).

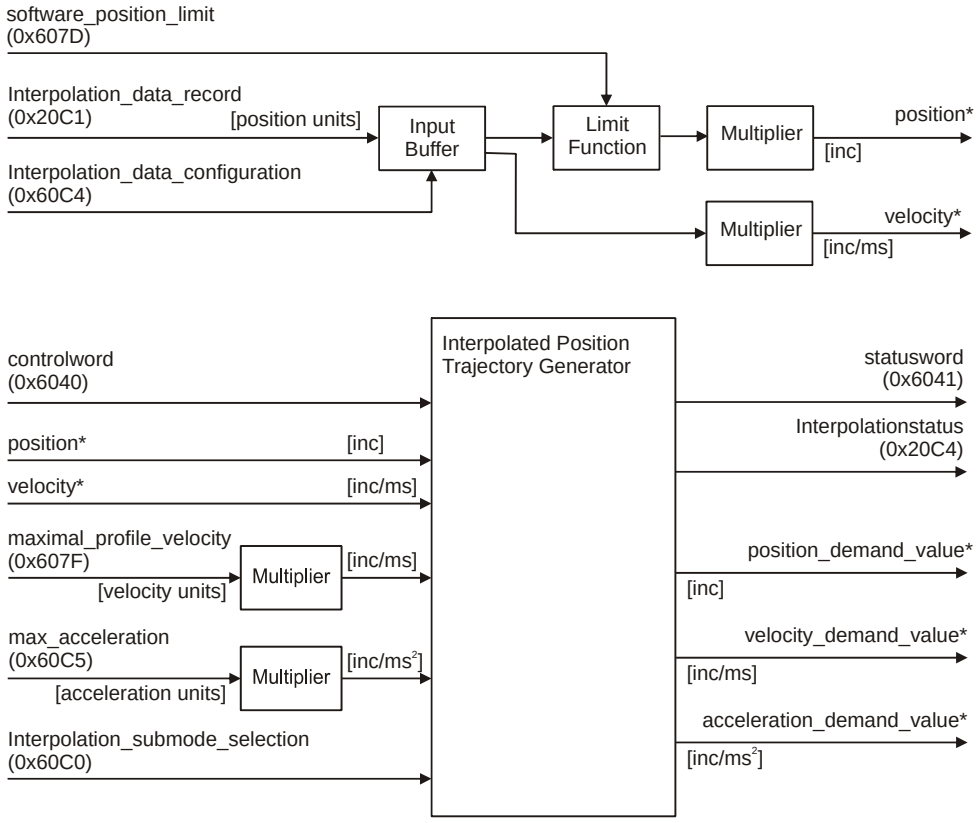


Figure 3: Interpolation Controller

3.1 Interpolated position data buffer

The PVT reference points will be sent in a manufacturer specific 64bit data record of a complex data structure to a FIFO object.

3.1.1 Definition of complex data structure 0x0040

MSB LSB

Time (unsigned8)	Velocity (signed24)	Position (signed32)

Table 1: IPM data buffer entry structure

3.1.2 Structure of the FIFO

The FIFO is implemented by a circular buffer with the length of 64 entries.

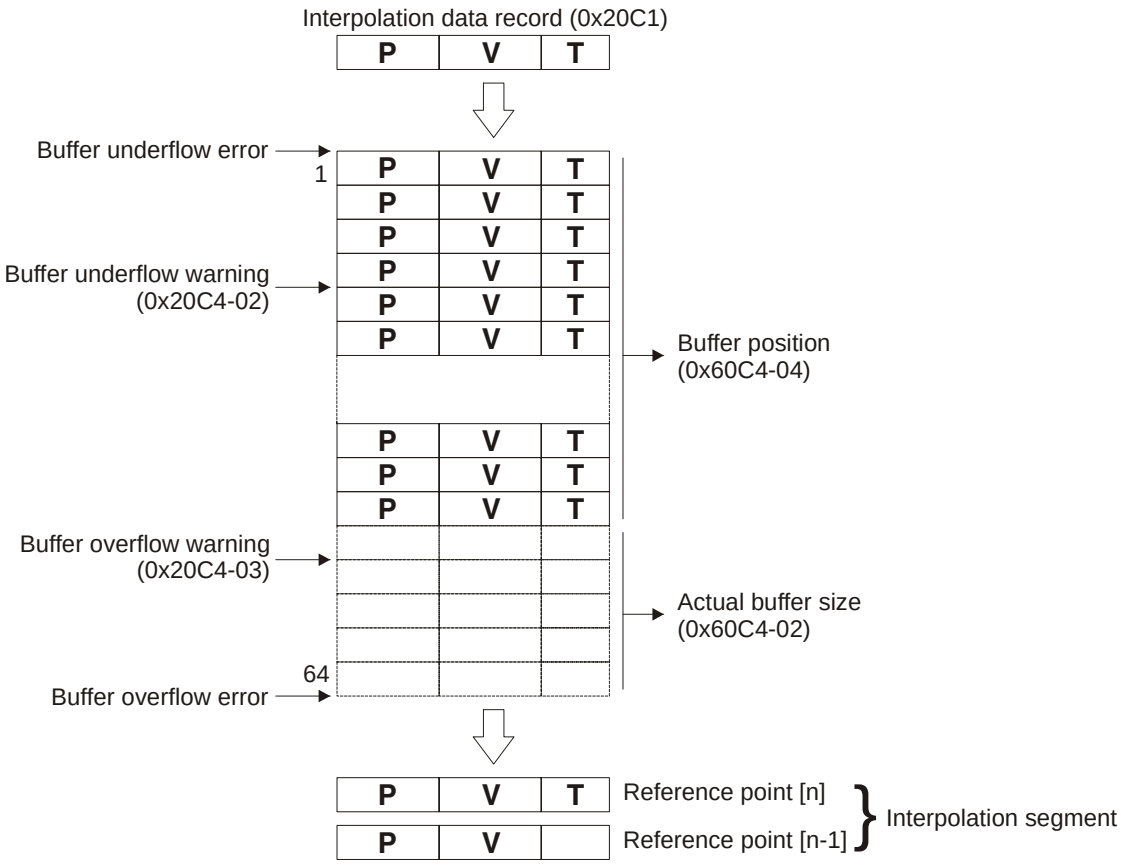


Figure 4: Interpolation buffer FIFO organization

3.2 Interpolated position mode FSA

The interpolated position finite state automaton is a sub FSA of the *Operation enable* state.

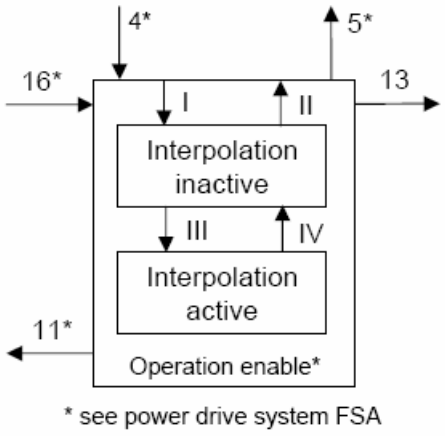


Figure 5: Interpolated position mode FSA

FSA state	Function
Interpolation inactive	The drive device will accept input data and will buffer it for interpolation calculations, but does not move the axis
Interpolation active	The drive unit will accept input data and it moves the axis

Table 2: 'Interpolated Position Mode' FSA states and supported functions

Transition	Event(s)	Action(s)
I	*ip* mode selected (see object 6060h)	clear data buffer
II	*ip* mode not selected (see object 6060h)	none
III	enable *ip* mode: set bit 4 of the controlword to 1	none
IV	disable *ip* mode: set bit 4 of the controlword to 0 or ip data record with time = 0	none

Table 3: 'Interpolated Position Mode' Transition events and actions

3.3 Configuration parameters

Parameter	Index	Description
Interpolation sub mode	0x60C0	This object indicates the actually chosen interpolation mode.
Interpolation time period	0x60C2	This object indicates the configured interpolation cycle time.
Interpolation data configuration	0x60C4	This object provides the maximum buffer size, indicates the configured buffer organization of interpolation data, and provides objects to define the size of data record and to clear the buffers.
Software position limit	0x607D	Contains the sub-parameters *min position limit* and *max position limit*. These parameters define the absolute position limits for the position demand value. Every new target position will be checked against these limits.
Position Window	0x6067	This function offers to define a position range around a target position to be regarded as valid. If the drive is within this area for a specified time the related control bit 10 'Target Reached' in the Statusword is set.
Position Window Time	0x6068	These parameters define the time for the position window.
Profile Velocity	0x6081	If the calculated velocity from the interpolation exceeds this profile velocity a warning bit in the Interpolation buffer status word will be set
Profile Acceleration	0x6083	If the calculated acceleration from the interpolation exceeds this profile acceleration a warning bit in the Interpolation buffer status word will be set
Maximal Profile Velocity	0x607F	If the calculated velocity from the interpolation exceeds this maximal profile velocity an error bit in the Interpolation buffer status word will be set and the device goes to Fault reaction state
Maximal Acceleration	0x60C5	If the calculated acceleration from the interpolation exceeds this maximal profile acceleration an error bit in the Interpolation buffer status word will be set and the device goes to Fault reaction state
Interpolation status	0x20C4	The Interpolation buffer under- and overflow warning level is configured in subindex 2 and 3 of this object.

Table 4: 'Interpolated Position Mode' Configuration parameters

3.4 Commanding parameters

Parameter	Index	Description
Controlword	0x6040	The profile position mode will be controlled by a write access to the mode dependent bits of the Controlword.
Interpolation data record	0x20C1	This object contains a FIFO to feed PVT reference points to the data buffer.

Table 5: 'Interpolated Position Mode' Commanding parameters

3.4.1 Controlword (Interpolated Position Mode specific bits)

The Controlword is a combination of operation mode dependent and mode independent bits. The mode independent bits are described in the EPOS2 Firmware Specification chapter 8.1.3 and 14.67 and the control bits of the IPM are described below.

Bits 15 - 9	Bit 8	Bit 7	Bit 6 - 5	Bit 4	Bits 3 - 0
(see FwSpec)	Halt	(see FwSpec)	reserved (0)	Enable ip mode	(see FwSpec)

Table 6: 'Interpolated Position Mode' specific Controlword

Name	Value	Description
Enable ip mode	0	Interpolated position mode inactive
	1	Interpolated position mode active
Halt	0	Execute instruction of Bit4
	1	Stop axis with profile deceleration

Table 7: 'Interpolated Position Mode' bits of the Controlword

3.5 Output parameters

Parameter	Index	Description
Interpolation status	0x20C4	The statusword of the interpolation mode is placed in subindex 1 of this object.
Statusword	0x6041	The interpolated position mode state can be observed by the specific bits of Statusword.
Position demand value	0x6062	The position demand value is the output of the trajectory generator. This value is the input for the position control function.

Table 8: 'Interpolated Position Mode' Output parameters

3.5.1 Statusword (Interpolated Position Mode specific bits)

The Statusword is a combination of operation mode dependent and mode independent bits. The mode independent bits are described in the EPOS2 Firmware Specification chapter 8.1.1 and 14.68 and the status bits of the IPM are described below.

Bits 15, 14	Bit 13	Bit 12	Bit 11	Bit 10	Bits 9 - 0
(see FwSpec)	reserved	ip mode active	(see FwSpec)	Target reached	(see FwSpec)

Table 9: 'Interpolated Position Mode' specific Statusword

Name	Value	Description
Target reached	0	Halt = 0: Target position not (yet) reached Halt = 1: Axle decelerates
	1	Halt = 0: Target position reached Halt = 1: Velocity of axle is 0
ip mode active	0	ip mode inactive
	1	ip mode active

Table 10: 'Interpolated Position Mode' bits of the Statusword

3.6 Detailed Object description

3.6.1 COB-ID Time Stamp Object

Name	COB-IB Time Stamp Object	
Index	0x1012	
Subindex	0x00	
Type	UNSIGNED32	
Access	RW	
Default Value	0x00000100	
Value range	0x00000100	0x00000100
PDO Mapping	No	

Description
This object defines the COB-ID of the Time-Stamp Object (TIME). On the EPOS2 this value is constant.

3.6.2 High Resolution Time Stamp

Name	High Resolution Time Stamp	
Index	0x1013	
Subindex	0x00	
Type	UNSIGNED32	
Access	RW	
Default Value	-	
Value range	-	-
PDO Mapping	Yes	

Description
This object contains the timestamp of the last received SYNC Object [1us]. The resolution of the device internal motion clock timer depends on the selected CAN bitrate (bit time) e.g. 1us at 1Mbit/s. After a write access to this object the EPOS2 calculates the difference between the received timestamp and the internal latched timestamp of the SYNC Object. This time difference is used as correction for the IPM time calculations.

3.6.3 Interpolation data record

Name	Interpolation data record	
Index	0x20C1	
Subindex	0x00	
Type	complex data structure 0x0040	
Access	WO	
Default Value	-	
Value range	-	-
PDO Mapping	Yes	

Description
This object sets PVT reference points in the interpolated position mode in the cubic spline interpolation sub-mode. The position is given absolute in [Position units] (typically [qc]), the velocity is given in [Velocity units] (typically [rpm]), and the time is given in [ms]. The object structure is defined in *Definition of complex data structure 0x0040*

MSB		LSB
Time (unsigned8)	Velocity (signed24)	Position (signed32)

Table 11: IPM data buffer record structure

Remarks
This object is normally used to feed PVT reference points to the drive while a PVT motion is executing. Therefore the object should be mapped to a RxPDO with transmission type of 255 (asynchron).
In the *Interpolation active* state at least two data records have to be in the FIFO. Otherwise a *Queue underflow* Emergency will be launched and the drive changes to *Fault reaction* state.
A data record with time = 0 changes the state to *Interpolation inactive* without any error.

3.6.4 Interpolation status

Name	Interpolation status	
Index	0x20C4	
number of entries	0x03	

Name	Interpolation buffer status	
Index	0x20C4	
Subindex	0x01	
Type	UNSIGNED16	
Access	RO	
Default Value	-	
Value range	-	-
PDO Mapping	Yes	

Description
This object gives access to status information about the IP input data buffer.

Bits 15	Bit 14	Bit 13 - 10	Bit 9 - 8	Bit 7 - 4	Bits 3 - 0
Ip Mode active	Buffer enabled	reserved (0)	IPM buffer errors	reserved (0)	IPM buffer warnings

Table 12: Interpolation buffer status word

Name	Bit	Value	Description
Underflow Warning	0	0	No buffer underflow warning
		1	Buffer underflow warning level (0x20C4-2) is reached
Overflow Warning	1	0	No buffer overflow warning
		1	Buffer overflow warning level (0x20C4-3) is reached
Velocity Warning	2	0	No profile velocity violation detected
		1	IPM velocity greater then profile velocity (0x6081) detected
Acceleration Warning	3	0	No profile acceleration violation detected
		1	IPM acceleration greater then profile acceleration (0x6083) detected
Underflow Error	8	0	No buffer underflow error
		1	Buffer underflow error (→ trajectory abort)
Overflow Error	9	0	No buffer overflow error
		1	Buffer overflow error (→ trajectory abort)
Velocity Error	2	0	No maximal profile velocity violation detected
		1	IPM velocity greater then maximal profile velocity (0x607F) detected (→ trajectory abort)
Acceleration Error	3	0	No maximal profile acceleration violation detected
		1	IPM acceleration greater then maximal profile acceleration (0x60C5) detected (→ trajectory abort)
Buffer enabled	14	0	Disabled access to the input buffer
		1	Access to the input buffer enabled
Ip Mode active	15	0	ip mode inactive (same as bit 12 in statusword)
		1	ip mode active

Table 13: Interpolation buffer status bits

Name	Interpolation buffer underflow warning	
Index	0x20C4	
Subindex	0x02	
Type	UNSIGNED16	
Access	RW	
Default Value	4	
Value range	0	63
PDO Mapping	No	

Description
This object gives lower signalization level of the data input FIFO. If the filling level is below this border the warning flag (bit 0) in the Interpolation buffer status will be set.

Name	Interpolation buffer overflow warning	
Index	0x20C4	
Subindex	0x03	
Type	UNSIGNED16	
Access	RW	
Default Value	60	
Value range	1	64
PDO Mapping	No	

Description
This object gives the higher signalization level of the data input FIFO. If the filling level is above this border the warning flag (bit 1) in the Interpolation buffer status will be set.

3.6.5 Interpolation sub mode selection

Name	Interpolation sub mode selection	
Index	0x60C0	
Subindex	0x00	
Type	INTEGER16	
Access	RW	
Default Value	-1	
Value range	-1	-1
PDO Mapping	No	

Description
This object shall indicate the actually chosen interpolation mode.

Interpolation Sub Mode	Description
-32768 to -2	Manufacturer-specific (reserved)
-1	cubic spline interpolation (PVT)
0	Linear interpolation (not yet implemented)
1 to 32767	reserved

Table 14: Interpolation Sub Mode Definition

3.6.6 Interpolation time period

Name	Interpolation time period	
Index	0x60C2	
number of entries	0x02	

Name	Interpolation time period value	
Index	0x60C2	
Subindex	0x01	
Type	UNSIGNED8	
Access	RW	
Default Value	1	
Value range	1	1
PDO Mapping	No	

Name	Interpolation time index	
Index	0x60C2	
Subindex	0x01	
Type	INTEGER8	
Access	RW	
Default Value	-3	
Value range	-3	-3
PDO Mapping	No	

Description
This object indicates the configured interpolation cycle time. The interpolation time period (sub-index 0x01) value is given in $10^{(\text{interpolation time index})}$ s(econds). The interpolation time index (sub-index 0x02) is dimensionless.

3.6.7 Interpolation data configuration

Name	Interpolation data configuration	
Index	0x60C4	
number of entries	0x06	

Name	Maximum buffer size	
Index	0x60C4	
Subindex	0x01	
Type	UNSIGNED32	
Access	RO	
Default Value	-	
Value range	64	64
PDO Mapping	No	

Description
This object provides the maximal buffer size and is given in interpolation data records.

Name	Actual buffer size	
Index	0x60C4	
Subindex	0x02	
Type	UNSIGNED32	
Access	RO	
Default Value	64	
Value range	0	64
PDO Mapping	Yes	

Description
This object provides the actual free buffer size and is given in interpolation data records.

Name	Buffer organisation	
Index	0x60C4	
Subindex	0x03	
Type	UNSIGNED8	
Access	RW	
Default Value	0	
Value range	0	0
PDO Mapping	No	

Description
The value 0 of this object indicates a FIFO buffer organisation.

Value	Description
0	FIFO buffer
1	Ring buffer (not supported)
2 to 255	reserved

Table 15: Buffer Organisation Definition

Name	Buffer position	
Index	0x60C4	
Subindex	0x04	
Type	UNSIGNED16	
Access	RW	
Default Value	0	
Value range	0	64
PDO Mapping	No	

Description
This object provides the used buffer space and is given in interpolation data records. Writing to this object has no effect.

Name	Size of data record	
Index	0x60C4	
Subindex	0x05	
Type	UNSIGNED8	
Access	WO	
Default Value	-	
Value range	8	8
PDO Mapping	No	

Description
The interpolation data record size is 8 bytes.

Name	Buffer clear	
Index	0x60C4	
Subindex	0x06	
Type	UNSIGNED8	
Access	WO	
Default Value	0	
Value range	0	1
PDO Mapping	No	

Description
If 0 is written to this object the data buffer is cleared and the access to it is denied. If 1 is written the access to the data buffer is enabled.

Related Objects
Interpolation status

Value	Description
0	clear input buffer (and all data records) Access disabled
1	Enable access to the input buffer for the drive functions
2 to 255	reserved

Table 16: Clear Buffer Value Definition

3.7 Typical IPM commanding sequence

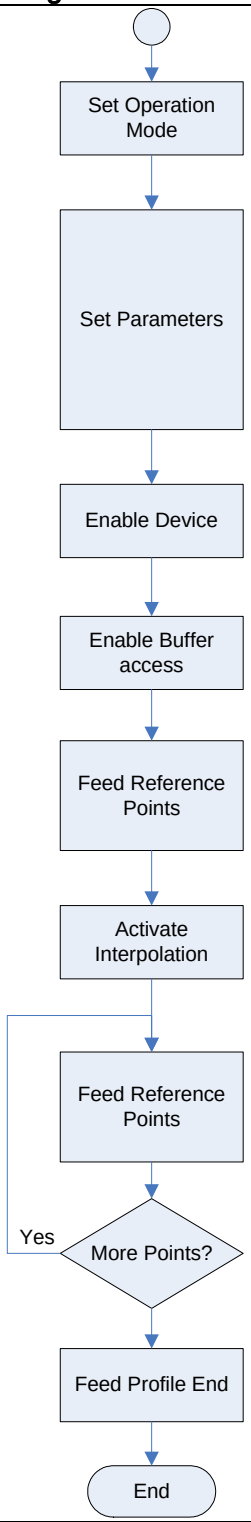
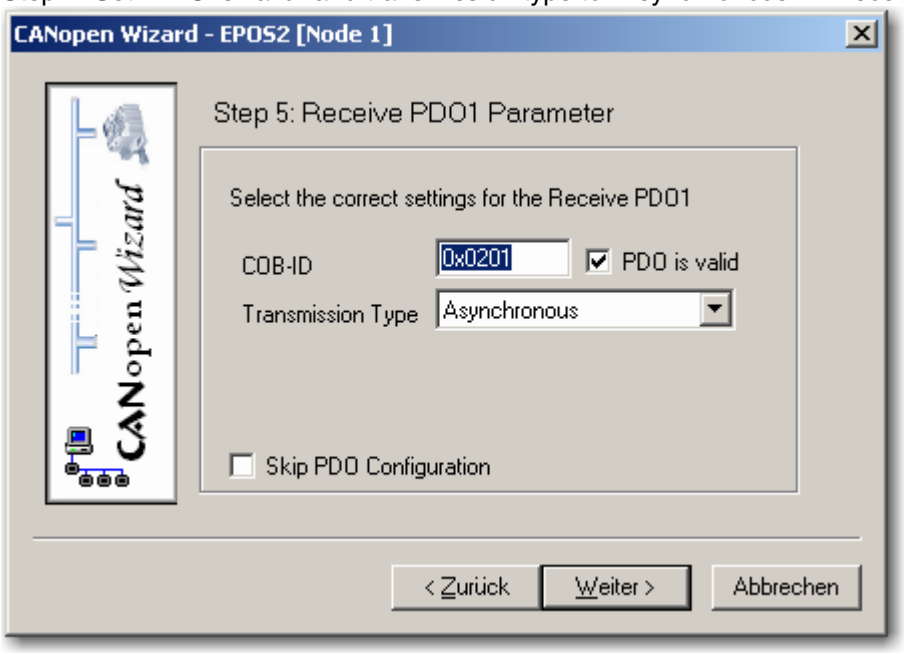
Diagram	Object name	Object	User value [default value]
			
Set Operation Mode	Modes of Operation	0x6060-00	0x07 (Interpolated Position Mode)
Set Parameters	Max. Following Error Min. Position Limit Max. Position Limit Max. Profile Velocity Max. Acceleration Profile Velocity Profile Acceleration Quick Stop Deceleration	0x6065-00 0x607D-01 0x607D-02 0x607F-00 0x60C5-00 0x6081-00 0x6083-00 0x6084-00	Application specific [2000 qc] Application specific [-2147483648 qc] Application specific [2147483647 qc] Motor specific [25000 rpm] Application specific [4294967295 rpm/s] Application specific [1000 rpm] Application specific [10000 rpm/s] Application specific [10000 rpm/s]
Enable Device	Controlword (Shutdown) Controlword (SwitchOn)	0x6040-00 0x6040-00	0x0006 0x000F
Enable Buffer access	Buffer clear	0x60C4-06	0x01
Feed Reference Points	Interpolation data record	0x20C1-00	Reference points (PVT) (minimum 2 points!)
Activate Interpolation	Controlword (enable ip mode)	0x6040-00	0x001F
Feed Reference Points	*if* (Interpolation buffer status) *do* Interpolation data record *until* (Interpolation buffer status)	0x20C4-01 0x20C1-00 0x20C4-01	Bit 0 == 1 (Underflow Warning) Reference point (PVT) Bit 1 == 1 (Overflow Warning)
Yes / More Points?			
Feed Profile End	Interpolation data record	0x20C1-00	Reference point (PVT) with time = 0
End			

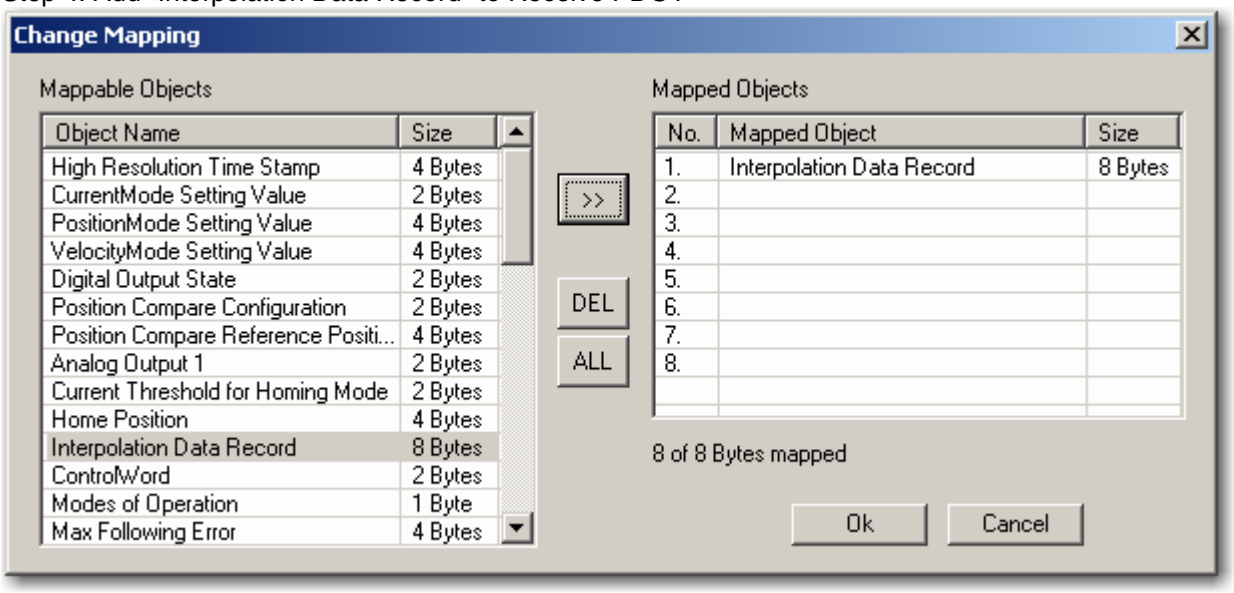
Table 17: Typical Commanding sequence

During the interpolation is active the feeding of new reference points is the main task. To minimize the communication overhead it makes sense to map the “Interpolation data record” in a (asynchronous) receive PDO. If the “Interpolation buffer status” is mapped to an event trigger transmit PDO (maybe together with the Statusword) the processing of the reference point feeding could be implemented simpler.

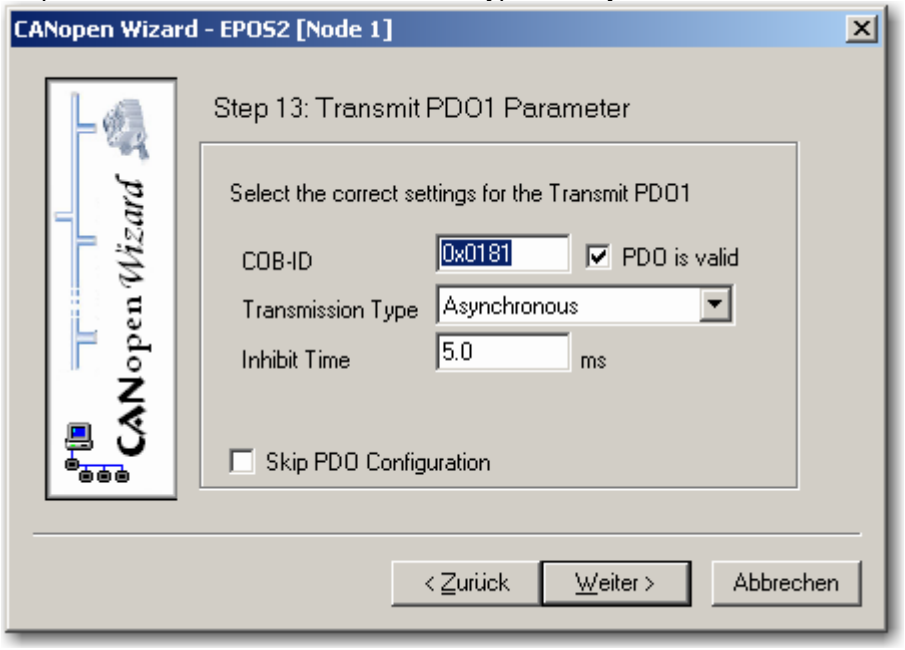
Use CANopen Wizard in Epos Studio for configuration the PDO mapping.
Step 1: Select "Restore Default COB-IDs" in Step 4 of CANopen Wizard
Step 2: Set "PDO is valid" and transmission type to "Asynchronous" in Receive PDO1 Parameter



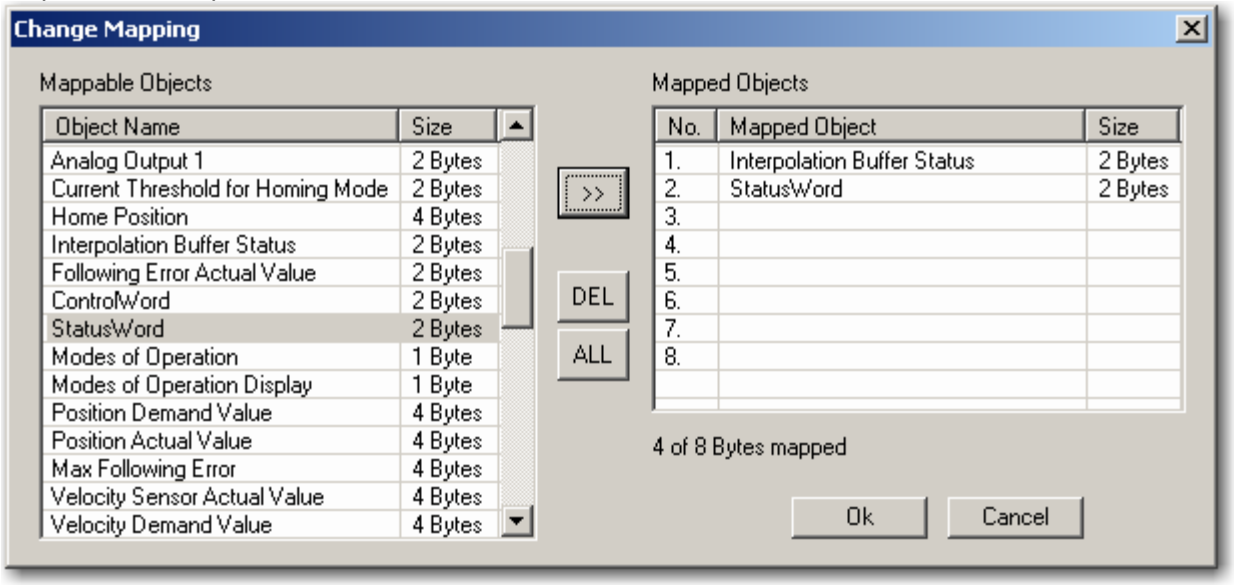
Step 3: Delete all mapped Object in "Change Mapping" window
Step 4: Add "Interpolation Data Record" to Receive PDO1



Step 5: Set "PDO is valid", transmission type to "Asynchronous" and "inhibit time" to e.g. 5.0 ms



Step 6: Delete all mapped Object in "Change Mapping" window
Step 7: Add "Interpolation Buffer Status" and "StatusWord" to Transmit PDO1



Step 8: go on to finish to CANopen Wizard

Motion Synchronisation
The interpolated position mode enables the synchronized motion of multiple axes. The motions of several slave axes can be synchronized if they all run in IPM, and they all have the same time.

In order to start several axes synchronously, map the *controlword* to a synchronous RPDO, and then use the mapped *controlword* to enable interpolation for all axes. Nothing will happen until the next SYNC. Then, all drives will enable interpolated motion at once, setting the SYNC arrival time as the “zero” time of the path specification.

If the axes have been synchronized by the *SYNC-Time stamp mechanism*, the moving axes should be relatively synchronized to the precision of microseconds.

If the CAN (SYNC) master is not able to produce the high resolution time stamp it is also possible to use one EPOS2 as clock master. For this the “High Resolution Time Stamp” object (0x1013) should be mapped to a synchronous transmit PDO on the clock master EPOS2. The other EPOS2 in the system has to be configured as

clock slaves. On this devices the “High Resolution Time Stamp” object is mapped to an asynchrony receive PDO with the very same COB-ID as the transmit PDO on the clock master.

Note: The resolution of the EPOS internal microsecond timer depends on the CAN bitrate due to a CAN controller internal hardware counter is used as timing reference. This hardware counter will be incremented by the bit time.

3.8 Interruption of interpolation mode in case of an error

If a currently running interpolation (index 0x20C4, subindex 0x03 "interpolation status" bit 15 "ip mode active" set) will be interrupted by the occurance of an error, the EPOS2 reacts as specified for the certain error (i.e. disabling the controller and changing to the state *switch on disabled*).
The interpolation can only be restarted by a re-synchronisation, because the state *Operation enable* has to be entered again, whereby the bit "ip mode active" will be cleared.