User manual

Absolute Position Indicator

with CANopen - interface

AP04S

Inhaltsverzeichnis

1. General Information 4

Definitions 4

Intended use 5

The AP04S product family 5

2. Brief description 5

In general 5

Display 6

Keyboard 6

Battery buffering 7

3. Start-up 7

Switching on the supply voltage 7

Configuration 8

Parameter list 8

Configuration via keyboard 8

Configuration via CAN interface 8

Sending the position value 9

Synchronous transmission 9

Asynchronous (cyclic) transmission 9

Stopping Transmission of the Position Value 9

4. General information on the CAN bus 10

CAN bus features 10

CANopen 10

The encoder device profile (CiA Draft Standard 406) 11

5. Data transfer according to the CANopen communication model 12

CANopen message structure 12

Function code 13

Node number (node ID) 13

Transmission of process data 13

From the AP04S to the bus master (position value + status byte) 13

From bus master to AP04S (target value) 14

Transfer of the SDO data (parameterization) 14

Emergency Service 16

Network Management Services (NMT) 18

Description of the NMT commands 18

Command byte 18

NMT status 18

The individual NMT states 19

State change 19

Heartbeat 20

6. Directory of objects 21

Overview of objects 21

Detailed description of objects 24

Object 1000h (Device Type) 24
Object 1001h (Error Register) 24
Object 1002h (Manufacturer Status Register) 24
Object 1003h (Pre-defined Error Field) 25
Object 1005h (COB ID SYNC message) 25
Object 1008h (Manufacturer Device Name) 26
Object 1009h (Manufacturer Hardware Version) 26
Object 100Ah (Manufacturer Software Version) 26
Object 1010h (Store Parameters) 26
Object 1011h (Load Default Parameters) 28
Object 1014h (COB ID Emergency Object) 28
Object 1017h (Producer Heartbeat Time) 29
Object 1018h (Identity Object) 29
Object 1200h (Server SDO Parameter) 30
Object 1400h (Receive PDO1 parameter, asynchronous operational mode) 30
Object 1401h (Receive PDO2 parameter, synchronous operational mode) 31
Object 1600h (Receive PDO1 Mapping Parameter) 31
Object 1601h (Receive PDO2 Mapping Parameter) 32
Object 1800h (Transmit PDO1 parameter, asynchronous operation mode) 32
Object 1801h (Transmit PDO2 parameter, synchronous operation mode) 33
Object 1A00h (Transmit PDO1 Mapping Parameter) 34
Object 1A01h (Transmit PDO2 Mapping Parameter) 35
Object 2001h (Manufacturer Offset) 35
Object 2002h (Zeroing of encoder value) 36
Object 2003h (Enable zeroing of encoder value via keyboard) 36
Object 2004h (Incremental measurement enable) 36
Object 5F09h (External Heartbeat Timer) 37
Object 5F0Ah (Node-ID) 37
Object 5F10h (Target window) 37
Object 5F11h (Decimal places) 37
Object 5F12h (Display orientation and LED) 38
Object 5F13h (Display divisor) 38
Object 5F14h (Loop width) 38
Object 5F15h (Loop direction) 39
Object 5F16h (Read target value) 40
Object 5F18h (External Heartbeat source) 40
Object 5F19h (AP04S status) 40
Object 5F1Bh (Free factor for resolution) 41
Object 6000h (Operating Parameters) 42
Object 6002h (Total Measuring Range) 43
Object 6003h (Preset value) 43
Object 6004h (Position value) 43
Object 6005h (Resolution) 44
Object 6200h (Cycle Timer) 45
Object 6500h (Operating Status) 45
Object 6501h (Resolution) 45
Object 6502h (Number of distinguishable revolutions) 46
Object 6503h (Alarms) 46
Object 6504h (Supported Alarms) 46
Object 6505h (Warnings) 47
Object 6506h (Supported Warnings) 47
Object 6507h (Profile and Software Version) 47
Object 6508h (Operating Time) 48
Object 6509h (Encoder Zeroing Value) 48
Object 650Ah (Module Identification) 48
Object 650Bh (Serial Number) 49

1. General Information

This user manual is valid for the absolute position indicator AP04S with firmware version 1.06 or higher and is intended to provide the necessary information for handling this device.

The ***Installation Instructions AP04S*** contains important information on warranty, safety, mechanical assembly, electrical connection as well as commissioning of the AP04S. Please read that information carefully as well.

The present ***User Manual*** will provide a detailed description of the functionality of the CANopen interface.
The communication options via RS485 are described in the ***Supplement to the Installation Instructions AP04S RS485.***

Definitions

This symbol precedes passages in the text that should be read particularly carefully to ensure flawless use of the device and to exclude dangers.

This symbol provides important information for proper handling of the display. Disregard of these hints may result in failures of functioning of the display or its environment.

⇒ This symbol indicates instructions for actions.

CAL	CAN Application Layer. Application layer (layer 7) in the CAN communication model
CAN	Controller Area Network
CiA	CAN in Automation. International Association of Users and Producers of CAN products.
COB	Communication Object. Transport unit in the CAN network (CAN message). Data is sent within a COB via the network.
COB ID	COB-Identifier. Unambiguous identification of a CAN message. The identifier determines the priority of the COB on the network.
ID	Identifier, see COB ID
LSB	Least significant bit/byte
MSB	Most significant bit/byte
NMT	Network Management. Service element of CAL, responsible for initialization, configuration and error handling on the network.
PDO	Process Data Object. Object for exchanging process data.
RTR	Remote Transmission Request; data request telegram
SDO	Service Data Object; communication object that enables the master to access the object directory of a node.

SYNC Synchronization telegram. Bus stations respond to the SYNC command by sending their process values.

Figures if not explicitly stated otherwise, decimal values are given as figures without an extension (e. g. 1234), binary values are marked after the figure with a **b** (e. g. 19011b), hexadecimal values with an **h** (e. g. 280h).

Intended use

Together with an external sensor, the electronic position indicator AP04S constitutes a high-precision measurement system. The position indicator serves exclusively for processing and output of position values, processing and providing measured values as electronic output signals for an upstream control as well as for the display of target values and positioning aids. The AP04S must be used for such purposes exclusively.

- Conversion or alteration of the device not approved by SIKO is forbidden for safety reasons.
- Refrain from any operation that may compromise safety with the device.

The AP04S product family

At present, the product family of absolute indicators consists of the following 2 types:

- **AP04S with RS485 interface**
- **AP04S with CAN interface (CANopen)**

AP04S must be operated together with the magnetic sensor MS500H and a magnetic band MB500. Although designed with a bus interface, the position indicator is very compact.

The AP04S functions with the following communication protocols:

- **CAN (CANopen interface)**
- **SN3 (RS485 with SIKONETZ3 protocol)**
- **SN4 (RS485 with SIKONETZ4 protocol)**
- **SSP (RS485 with Service Standard protocol)**

2. Brief description

In general

The present device is an absolute position indicator with a plug connector for a magnetic sensor MS500H intended for direct linear distance measurement (with magnetic band MB500). Set point and actual value are displayed via the 2-line LC display. In case of non-conformance of actual value and set point a direction indication (arrow) is shown. The arrow indicates the direction of sensor movement necessary for the target value to be reached. The user can set the threshold of deviation where the arrows will be shown. Addionally, various visualization tasks can be realized by means of two coloured LEDs (green and red).

The device parameters can be adjusted by means of 3 keys. The set point can be changed and individual device parameters adjusted via the integrated CAN bus interface.

Scanning is magnetically incremental. In the currentless state, scanning and saving of changes of the position value are battery-supported. The battery can be replaced. The battery symbol on the display will blink when the battery voltage falls below a critical level. If the battery voltage falls below a minimum level, the symbol will glow permanently.
If no sensor is connected (only RS485) or if the sensor is lifted from the band, an error will be detected and the position value displayed with a blinking "Error". This condition will also be retained beyond failure of power supply. The error must be corrected by zeroing (see key functions) after having checked the sensor connection or sensor position, respectively.
Display and interface are active with external power supply only.

Display

2 lines of each 5 7-segment readings

4 special characters: "<", ">", incremental measure symbol ⟼⟼; Battery symbol ▭

Displayable number range:
-19999 bis 99999

If this number range is exceeded, the "FULL" message will be displayed. However, the value is available for transmission via interface.

Keyboard

The AP04S has the ✱ -, ⬆ - and ⬅ keys, which serve for device parameter adjustment.

⬆ - Key

By pressing the ⬆ key, the incremental measurement function is switched on or off. During this action, the incremental measurement symbol ⟼⟼ is shown or hidden on the display. For this purpose, the incremental measurement function must be enabled.

During configuration, the current value can be changed by means of the ⬆ key.

✱ - Key

If zeroing is enabled and the ✱ key actuated, "rESEt" will appear in the 2nd line of the display. This indication will blink for 5s. If the key is released within this period, the current position value will be maintained. The display stops blinking upon expiry of the the wait time and the current position value will be set to zero when the key is released.

Position value = 0 + calibration value + offset value.

During configuration the ✱ key serves for acknowledging the current value and switching over to the next parameter.

⬅ - Key

The ⬅ key has various functions.

By pressing the ⬅ key, the set bus address ("1" in the example) and baud rate (250 kbit/s) will be displayed.

E. g.:

Id 1
250

When actived during more than 15 s, AP04S will switch to configuration mode.

Display will then show the first configuration menu point.

Battery buffering

The battery makes possible the detection of currentless displacement. Battery life is approx. 5 to 8 years depending on the duration of battery operation (including storage) and frequency of currentless adjustments. Battery voltage is checked at intervals of approx. 5 min. If battery voltage drops below a specified value, the battery symbol will blink on the display. The battery is nearly empty. If the battery voltage continues to drop, will be displayed permanently. The battery should be replaced as soon as the battery symbol appears on the display. The battery can be replaced by the SIKO distribution partners or at the SIKO main factory. For battery replacement it is mandatory to follow the instructions of the ***Installation Instructions***.

3. Start-up

Prior to starting up the display the following work should be performed:

- Correct assembly (see AP04S Installation instructions)
- Correct mounting and connection of magnetic band and sensor (see sensor Installation instructions)
- Correct connection of the supply and bus lines (see AP04S Installation instructions)
- Setting of the Node ID (must be present in the system only once)
- Setting of the CAN baud rate valid for the system
- Setting of additional configuration parameters if necessary

Switching on the supply voltage

The AP04S will be initialized after switching on the supply voltage.

During initialization, a display and LED test is carried out and the configuration parameters are loaded from the non-volatile memory to the main memory of the controller.

With the display still unconfigured all parameters are set to their default values. See to it that the bus will be connected only after correct adjustment of baud rate and ID. The AP04S functions with the data last parameterized.

After completing the initialization procedure, the AP04S with CAN interface sends a specific NMT command, the **Boot-Up Message,** which informs the system about the availability of the display. The AP04S is now in the **Pre-Operational** Mode. In this state, the display can be parameterized via SDO commands in accordance with the requirements of the application. This applies to configuration parameters as well as to the way it makes available to the system its position values (asynchronous or synchronous data transmission).

If no boot-up message can be sent because the baud rate was set wrongly, the AP04S will be reinitialized completely (warm start) and will try again to send the message. This becomes visible by a repeated display test. If no bus is connected, the AP04S will also try permanently to send the boot-up message but will only be reinitialized after a defined number of failed attempts.

Configuration

Parameter list

For a detailed description of the parameters refer to section "Detailed description of objects".

Parameter	Value range	Default	Meaning / Note	Object
Id	1 … 127	1	bus address	5F0Ah
bAUd	125, 250, 500, 1000	250	baud rate in kbit/s	-
rES	0.01; 0.1; 1; 10 mm 0.001; 0.01; 0.1; 1 inch; FACt	0.01 mm	resolution	6005h
FACt [1)]	0.0000 ... 2.9999	1.0000	resolution with free factor [2)]	5F1Bh
dIV [1)]	1, 10, 100, 1000	1	Display divisor [2)]	5F13h
dIr	POS, nEG	POS	counting direction (increasing value when sensors moves towards sensor cable)	6000h
dEZ	0, 0.0, 0.00, 0.000, 0.0000	0	display of decimal places	5F11h
OFFSt	-9999 … +9999	0	offset value	2001h
CAL	-9999 … +9999	0	calibration value	6003h
F0SEt	0, 1	1	zeroing enable	2003h
FCEtt	0, 1	1	incremental measurement enable	2004h
InPOS	-9999 … +9999	5	deviation window from setpoint to actual value	5F10h
Loop	-9999 … +9999	0	loop reversal point (in display unit)	5F14h
LPdIr	dIr, POS, nEG,	dIr	positioning for loop	5F15h
GrEEn	0 (OFF), 1 (ON)	1	green LED is lighted when target window is reached	5F12h
rEd	0 (OFF), 1 (ON)	1	red LED is lighted when position outside target window	5F12h
FLASh	0 (OFF), 1 (ON)	0	LED blinks when switched on	5F12h
CodE	0 … 99999 00100 11100	0	for SIKO-internal test purposes / diagnosis calibration travel load factory settings	- - 1011h
dISPL	0, 180	0	display orientation	5F12h

[1)] only with resolution ("rES") = "FACt"
[2)] see resolution with free factor

Configuration via keyboard

The required parameters are set in the configuration mode.

On the 1st line of the display, the parameter will be shown and on the 2nd line the respective value will be displayed.

By actuating the ↑ key, the current value can be changed at the blinking position in case of multi-digit values, or else completely (e. g. "POS" -> "nEG").

The ← key serves for switching to the next digit in case of multi-digit numbers.

By pressing the ✱ key, the set value is acknowledged and saved non-volatilely. If no key is pressed, the configuration mode will be exited after approx. 30 s without saving the latest value displayed, i. e. the original value will be maintained.

Configuration via CAN interface

Except for the baud rate all parameters can be configured via the CAN interface. For a detailed description of all parameter objects refer to section "6 Directory of objects".

Sending the position value

Before the display can send its position value, the AP04S must be switched to the **Operational Mode** via the **Node Start** NMT command.

COB ID	Command byte	Node number
0h	1h	0h ... 1Fh (0 ... 31)

If the Node ID of the display is indicated as the node number, then only this display will start. If the value 0 is transmitted for the node number, then all devices connected to the bus will start.

Now the display can transmit its position value as specified via PDO1 or PDO2, respectively.

Synchronous transmission

The device supports this type of transmission with its factory setting.

If the AP04S receives a SYNC telegram in the operational mode, the display will respond with the position value plus the status byte. For a more detailed description of transmission refer to section "Transmission of process data".

To make possible synchronous transmission of the position value, the PDO2 must be enabled (bit31 of the COB ID PDO2 to 0 = default). Furthermore, a value between 1 and 240 (= F0h) must be written in object 1801h, sub-index 2 (1 = default).

Another possibility of transmitting the PDO2 consists in the response to a RTR. To this purpose, the value 253 (= FDh) must be written to object 1801h, sub-index 2.

Asynchronous (cyclic) transmission

PDO1 is responsible for this type of transmission. The position value (plus status byte) is cyclically sent in accordance with the time parameterized in object 1800h, sub-index 5.

Stopping Transmission of the Position Value

General:

To stop data transmission from the display, the display can be switched back to the **Stopped Mode** or to the **Pre-Operational Mode**:

Stop Mode command

COB ID	Command byte	Node number
0h	2h	0h ... 1Fh (0 ... 31)

Pre-Operational Mode command

COB ID	Command byte	Node number
0h	80h	0h ... 1Fh (0 ... 31)

All devices connected to the bus are addressed via node address 0.

Synchronous transmission:

Naturally, there is no synchronous transmission if no SYNC telegram is received or no RTR is obtained.

Asynchronous transmission:

Asynchronous, i. e. timer-controlled transmission is suppressed if the timer value is set to 0 (see object 1800h).

4. General information on the CAN bus

Originally, the CAN bus (CAN: Controller Area Network) was developed by Bosch and Intel for fast and low-cost data transmission in the car industry. Today it is also used in industrial automation. The CAN bus is a field bus, which enables communication of devices, actuators and sensors of different manufacturers. The standards are defined by the Association CAN in Automation (CiA).

CAN bus features

- Bus medium is a shielded twisted pair cable.
- The CAN bus is a multi-master bus, i. e. several CAN stations can request the bus at the same time. The message with the highest priority (determined by the identifier) prevails.
- Data rate up to 1 bit/s permissible (with 40 m network range).
- Closed network on both sides.
- Theoretically, up to 127 stations possible on one bus; however, practically only up to 32 stations due to the driver.
- Message-oriented communication: The message is marked with a message identification (identifier). By means of the identifier, all bus stations check whether the message is relevant for each of them.
- All bus station receive each message at the same time. Therefore, synchronization is possible.
- The identifier determines the priority of the message. The lower the value of the identifier, the higher is the priority of the message. This enables fast transmission of important messages via the bus.
- High transmission safety thanks to various error identification mechanisms, which complement each other.
- Localization of faulty or disabled bus stations. The CAN protocol includes function monitoring of bus stations. The functionality of the latter will be limited or disconnected from the network if they are faulty.

CANopen

The CANopen profile was developed on the basis of the layer 7 specification CAL (CAN Application Layer) under the direction of the Steinbeis Transferzentrum für Automatisierung (Transfer centre for automation). Compared to CAL, only the functions appropriate for this use are included in CANopen. Thus, CANopen is a subset of CAL optimized for the application and enables a simplified system design as well as the use of simplified devices. CANopen has been optimized for fast data exchange in real-time systems.

The organization CAN in Automation (CiA) is responsible for the applicable standards of the respective profiles.

The position indicator AP04S with CANopen interface fulfils the conditions specified in the "CANopen Application Layer and Communication Profile" (CiA Draft Standard 301, version 4.02) and in the "CANopen Device profile for encoders" (CiA Draft Standard 406, version 3.1) (CAN 2.0A).

CANopen enables:

- easy access to all device and communication parameters,
- synchronisation of several devices,
- automatic configuration of networks
- cyclic and event-triggered data traffic

CANopen consists of four communication objects (COB) with different features:

- Process Data Objects (PDOs) for real-time data.
- Service Data Objects (SDOs) for parameter and program transfer,
- Network Management (NMT),
- Predefined objects (for synchronization, emergency message)

The description of the device functionality via an object directory is the central element of the CANopen standard. The object directory is subdivided into an area containing general information on the device (device identification, manufacturer's name, etc.) and communication parameters, and an area describing the specific device functionality.

An entry ("object") of the object directory is identified via a 16bit index and an 8b bit sub-index. By means of these entries, the "application objects" of a device (e. g. position value with encoders) are made accessible in a standardized form via the network.

The functionality and features of a CANopen device can be described in the ASCII format as a standardized "Electronic Data Sheet" (**EDS**).

The EDS file (CANopen configuration file) of the AP04S can be downloaded from the homepage of SIKO GmbH (www.siko-global.com/p/ap04s).

The encoder device profile (CiA Draft Standard 406)

This profile describes a manufacturer-independent and binding specification of the interface for rotary encoders. The profile defines which CANopen functions are used and how they are to be used. This standard enables the creation of an open and manufacturer-independent bus system.

The device profile is divided into two object classes:

- Standard class C1 describes all basic functions, which the encoder must contain,
- The extended class C2 contains a wide range of additional functions that must either be supported by these encoders (mandatory) or are optional. Thus, devices of the C2 class contain all the C1 and C2 mandatory functions as well as – manufacturer-dependent – additional, optional functions.

Additionally, an addressing range is defined in the profile for assignment of special proprietary functions.

The AP04S supports class C2.

5. Data transfer according to the CANopen communication model

The communication model underlying CANopen provides two types of communication mechanisms:

- Unconfirmed transfer of data having a length of max. 8 bytes **(Process Data Objects, PDOs).** These data is transferred with high priority (low COB identifier). PDOs are broadcast messages and provide their data to all addressees on the bus at the same time.
- Confirmed transfer also of longer data sets (parameters) between two stations with direct access to the entries of the addressee's object directory **(Service Data Objects, SDOs).** As a rule, these parameters are transferred acyclically (e. g. only once when the system is started) and have, therefore, low priority (= high COB identifier).

The priority of the message objects is determined via the COB identifier.

CANopen message structure

For easier management of the identifiers, CANopen uses the "Pre-Defined Connection Set". Here, all identifiers are defined in the object directory with standard values. However, the customer has the possibility of changing these identifiers via SDO access to meet his requirements. However, only 11 bit identifiers are supported (CAN 2.0A).

The 11bit identifier (COB identifier) consists of a 4bit function code and a 7bit node number:

Bit no.	10	9	8	7	6	5	4	3	2	1	0
Type	Function code				Node number (node ID)						
Assignment	x	x	x	x	0	0	x	x	x	x	x

Hint: Thus, a maximum of 127 different node numbers can be set (node number 0 is illegal!).

Hint: Only a maximum of 31 bus stations is permitted!

The function code informs about the type of message and its priority. The higher the value of the identifier, the lower the priority.

Function code

The following function codes have been defined in the "Pre-defined Connection Set" (only the function codes used by the AP04S are represented):

Object	Function code	Resulting COB ID	assigned communication parameter for index
NMT	0000b	0	-
SYNC	0001b	128 (80h)	1005h
EMERGENCY	0001b	128 (80h) + Node-ID	1014h
PDO1 (tx)[1]	0011b	384 (180h) + Node-ID	1800h
PDO1 (rx)[1]	0100b	512 (200h) + Node-ID	1400h
PDO2 (tx)[1]	0101b	640 (280h) + Node-ID	1801h
PDO2 (rx)[1]	0110b	768 (300h) + Node-ID	1401h
SDO (tx)[1]	1011b	1408 (580h) + Node-ID	1200h
SDO (rx)[1]	1100b	1536 (600h) + Node-ID	1200h
HEARTBEAT	1110b	1792 (700h) + Node-ID	1017h

[1] (tx) and (rx) seen from the position indicator

Node number (node ID)

The 7bit node number is set on the AP04S via configuration and displayed upon pressing the ⬅ key during operation.

Node number 0 is reserved and must not be changed by any node. Therefore, resulting node numbers are in the range of 1 … 127. Any freshly set node number is only taken over after the next reset/power-on of the encoder.

Ex works, the position indicator is delivered with node number 1.

Transmission of process data

The four PDO services, PDO1 (tx), PDO1 (rx), PDO2 (tx) and PDO2 (rx), are available.

From the AP04S to the bus master (position value + status byte)

PDO transfer from the display to the bus master (TPDO) can be initiated as a result of various events:

- asynchronous, controlled by an internal device timer
- synchronous as a response to a SYNC telegram
- as a response to a RTR telegram

Both PDOs provide the current position as well as a status byte of the display and are determined via objects 1800h, 1801h, 1A00h, 1A01h, 2800h, 2801h and 6200h.

With the AP04S, TPDO1 is assigned to asynchronous and TPDO2 to synchronous process data transfer. As a standard, TPDO2 is enabled after each power-on of the encoder and must be disabled on request via SDO.

Request of the position value via RTR telegram is also only possible via TPDO2.

The TPDO message has the following structure:

COB ID	Process data in binary code				
11bits	Byte 0 (LSB)	Byte 1	Byte 2	Byte 3	Byte 4 (MSB)
TPDO1: 180h+Node-ID TPDO2: 280h+Node-ID	Position value in two's complement representation see object 6004h				Status byte see object 5F19h

Synchronous data transfer (factory setting)

The AP04S is delivered with this type of transmission preset and the AP04S responds to a SYNC telegram received by sending the TPDO message.

To be able to send process data synchronously, a value between 1 and 240 (= F0h) must be written in object 1801h, sub-index 2.

In synchronous operation, the PDO2 is requested by a master via the SYNC telegram (SYNC-COB ID = 80h).

If the PDO2 is to be requested via an RTR telegram, then the value 253 (= FDh) must be written in object 1801h, sub-index 2.

Asynchronous data transfer

If a PDO is to be sent cyclically, then the cycle time must be entered into object 1800h, sub-index 5, in milliseconds. The PDO1 will not be sent if the value 0 ms is written. The function is disabled. The minimum value to be set is 1 (=1 ms).

From bus master to AP04S (target value)

By means of PDO transmission from the bus master to the AP04S (RPDO), the target value can be transferred to the display. The following PDOs are accepted.

COB ID	Process data in binary code			
11Bit	Byte 0 (LSB)	Byte 1	Byte 2	Byte 3 (MSB)
RPDO1: 200h+Node-ID RPDO2: 300h+Node-ID	Target value in 2-complement representation			

Transfer of the SDO data (parameterization)

The object directory of the position indicator can be accessed via an SDO message. All device parameters are stored in this object directory under standardized addresses (indexes) and can be written to and read by means of SDOs. SDOs are exclusively exchanged in the expedited request/response process between two subscribers.

Two SDO services are available:

- SDO (tx) (AP04S ➡ Master): **580h** + Node-ID
- SDO (rx) (Master ➡ AP04S): **600h** + Node-ID

The SDO identifiers cannot be changed!

SDO messages are set up as follows:

COB ID	Command	Index		Sub-index	Service data (parameters)			
SDO + Node-ID	Byte 0 (read / write)	Byte 1 (LSB)	Byte 2 (MSB)	Byte 3	Byte 4 (LSB)	Byte 5	Byte 6	Byte 7 (MSB)

For the meaning of index, sub-index and data please refer to *chapter,* "6 Directory of objects".

The command byte specifies the length of the service data (parameters). In the case of the AP04S the following command bytes are valid:

Command byte	Type	Function
23h	SDO (rx), Initiate Download Request, expedited	Send parameter to AP04S (data length = 4bytes)
2Bh	SDO (rx), Initiate Download Request, expedited	Send parameter to AP04S (2Bytes from 4 Datenbytes valid)
2Fh	SDO (rx), Initiate Download Request, expedited	Send parameter to AP04S (1Bytes from 4 Datenbytes valid)
60h	SDO (tx), Initiate Download Response	Acknowledgement of data acquisition to master
40h	SDO (rx), Initiate Upload Request	Request parameter from AP04S
42h	SDO (tx), Initiate Upload Response, expedited, unspecified number of bytes	Parameter to master (data length = 4bytes)
80h	SDO (tx), Abort Domain Transfer	AP04S reports error code to master

- An error message (command 80h) replaces the normal response in case of a fault.
- The error message includes communication protocol errors as well as object directory access errors (e. g. write attempt on read-only object, wrong index, etc.).

The error codes are described in the CANopen profile (DS 301) or in the encoder profile (DSP 406), respectively. The table below shows the error codes used in the AP04S:

Error code	Description
06010000h	Wrong access to an object.
06010001h	Read access to Write-Only
06010002h	Write access to Read-Only.
06020000h	Object doesn't exist in the object directory.
06070010h	Wrong data type, incorrect data length.
06090011h	Sub-index does not exist.
06090030h	Wrong value range of selected parameter.
06090036h	Maximum value smaller than minimum value.
08000020h	Parameters cannot be transferred to application or stored.
08000022h	Parameters cannot be transferred to application or stored due to the current device status.

SDO examples:

Request of value by a master with a slave ➡ Operating Status (object 6500h):

COB ID	Command	Index L	Index H	Sub-index	Data 0	Data 1	Data 2	Data 3
600h + Node-ID	40h	00h	65h	00h	x	x	x	x

Response to the request by the slave:

COB ID	Command	Index L	Index H	Sub-index	Data 0	Data 1	Data 2	Data 3
580h + Node-ID	42h	00h	65h	00h	a	b	c	d

Writing a value from master to a slave ➡ object 1800, sub-index 5 (Event Timer):

COB ID	Command	Index L	Index H	Sub-index	Data 0	Data 1	Data 2	Data 3
600h + Node-ID	23h	00h	18h	05h	E8h	03h	00h	00h

Response from slave to writing the value:

COB ID	Command	Index L	Index H	Sub-index	Data 0	Data 1	Data 2	Data 3
600h + Node-ID	60h	00h	18h	05h	00h	00h	00h	00h

Emergency Service

Internal device errors or bus problems trigger an emergency message. The corresponding telegram is set up as follows:

COB ID	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
80h + Node-ID	Error Code		Error Register	Alarms (object 6503h)		Warnings (object 6505h)		00h

If value "11h" is in the error register, the meaning of bytes 3 – 6 in the emergency telegram will be changed. The value "11h" indicates errors that have occurred during transfer of data on the CAN bus (see description "Error codes"). The encoder has changed to the "Error Passive" state.

With diminished interference on the CAN bus the encoder returns automatically to the normal state designated "Error active". Otherwise, if interference continues to increase, the encoder will change to the "bus off" state with subsequent restart characterized by a "boot-up message" and an additional "emergency message" (byte3 and byte4 = 0).

Emergency message in the case of bus errors:

COB ID	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
80h + Node-ID	Error Code		Error Register	Transmit Error Counter	Receive Error Counter	00h	00h	00h

As with the SDO error messages, pre-defined error messages are assigned to the EMERGENCY object as well. A subset of these error codes described in the CAN Application Layer DS301 is used by the AP04S. They are described in the table below:

Byte 0 ... Byte 1: Error Code

Error Codes	Description
0000h	No error
8120h	Encoder is in the Error Passive Mode
8140h	Recovered from Bus Off

Byte 2: Error Register

Bit Nr.	Description
0	Set bit indicates general error condition; bit is set with every error occurring
4	Communication error; is set when a CANbus communication error occurs (acknowledgement, form, CRC and stuff error)
8	Manufacturer-specific instrumental error (battery dead, sensor error)

Byte 3 ... Byte 4: Alarms

Bit Nr.	Description
0	Position value invalid if bit set (=1)
14	Battery warning (critical charge condition)
15	Battery alarm (battery dead)

Byte 5 ... Byte 6: Warnings

Bit Nr.	Description
4	Battery status critical

Byte 7: not used

Network Management Services (NMT)

The network management can be subdivided into two groups:

- NMT service for device control; serves for initializing, starting and stopping of the encoder,
- NMT service connection monitoring ("heartbeat").

Description of the NMT commands

The commands are transferred as unconfirmed objects (broadcast messages) and are set up as follows:

COB ID	Byte 1	Byte 2
0h	Command byte	Node number (node ID)

The COB ID for NMT commands is always zero (highest priority). The node ID is transferred in byte 2 of the NMT command.

The node number corresponds with the node ID of the desired station. With node number = 0, all bus stations are addressed.

Command byte

Command byte	Description	**State transition** (see State diagram, fig. 1)
01h	Start_Remote_Node; change from state "Pre-Operational" or "Stopped" to "Operational"	1
02h	Stop_Remote_Node; change to state "Stopped"	2
80h	Enter_PRE-OPERATIONAL_State; change to state "Pre-Operational"	3
81h	Re-initialization of CAN connection	4
82h	Reset AP04S (warm start)	5

NMT status

After initializing, the encoder is in the "Pre-Operational" state. SDO parameters can be read and written in this state. To request PDOs, the encoder must first be switched to the "Operational" state.

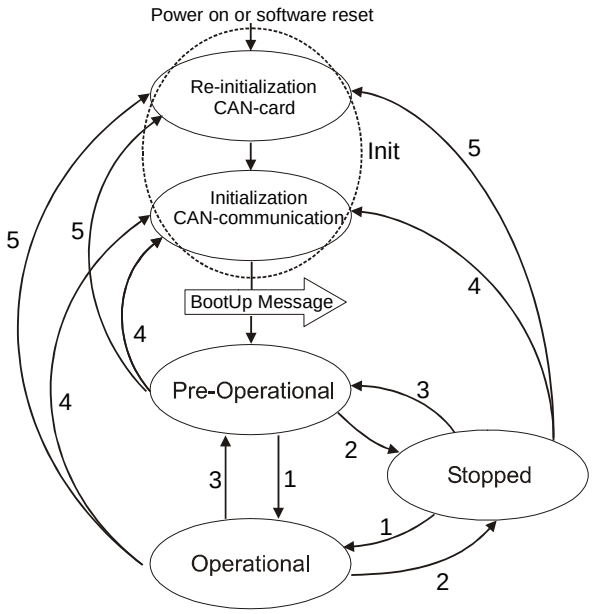


Fig. 1: CAN status diagram

The individual NMT states

Init:

After initialization, the encoder logs in at the CAN bus with a boot-up message. Afterwards, the encoder changes automatically to the "Pre-operational" state.

The COB ID of the boot-up message is made up of 700h and the node ID.

COB ID	Byte 0
700h + Node-ID	00h

Pre-Operational Mode:

SDOs can be read and written in the Pre-Operational Mode.

Operational Mode:

In the operational mode, the encoder sends the PDOs requested. Additionally, SDOs can be read and written.

Stopped Mode:

Only NMT communication is possible in the Stopped Mode. No SDO parameters can be read or written.

State change

The following applies to all commands listed below: If node number 0h is sent, the command will apply to all nodes connected.

Start Remote Node (1)

With the "Start_Remote_Node" command, the encoder is set to the "Operational Mode" state.

COB ID	Command byte	Node number
0h	1h	0h ... 1Fh (0 ... 31)

Stop Remote Node (2)

With the "Stop_Remote_Node" command, the encoder is set to the "Stopped" state.

COB ID	Command byte	Node number
0h	2h	0h ... 1Fh (0 ... 31)

Enter_PRE-OPERATIONAL-Mode (3)

Change to the "Pre-Operational" state.

COB ID	Command byte	Node number
0h	80h	0h ... 1Fh (0 ... 31)

Re-initialization of CAN parameters (4)

COB ID	Command byte	Node number
0h	81h	0h ... 1Fh (0 ... 31)

Re-initialization of the CAN card (5)

COB ID	Command byte	Node number
0h	82h	0h ... 1Fh (0 ... 31)

Heartbeat

Two optional monitoring mechanisms are intended for ensuring proper functioning of the CANopen network nodes: Each network node can be monitored by a higher-order master via the so-called "Node Guard" or, alternatively, announce its ability to communicate by cyclic sending of a so-called "heartbeat" message.

The "heartbeat" method is intended for the AP04S.

One or several network subscribers can receive this message and, thus, monitor the assigned subscriber.

In object 1017h, "Producer Heartbeat Time", the time of the heartbeat interval can be deposited. The value 0 disables heartbeat.

The heartbeat message consists of the COB ID and an additional byte. In this byte, the current NMT state is deposited.

COB ID	Byte 0
700h + Node-ID	NMT state

NMT states:

- 0: Boot-Up
- 4: Stopped
- 5: Operational
- 127: Pre-Operational

6. Directory of objects

In the object directory of a CANopen device, all features and parameters of this device are deposited.

Specific parameters of the objects directory are deposited in a power-failure-safe memory of the encoder and are copied into the main memory during power-on or re-initialization.

Access to the directory of objects is via the SDO services described in section "Transfer of the SDO data (parameterization)".

The object directory is subdivided into three separate areas:

- standard objects applicable to all CANopen instruments, 1h ... 1FFFh, (CiA DS 301)
- manufacturer-specific objects, 2000h ... 5FFFh
- device-specific objects, 6000h ... BFFFh, (CiA DS 406)

The address (index) pointing to each entry in the object directory is also standardized in the profiles except for the manufacturer-specific area. This fact ensures that all instruments always provide the functions described in the profile (standard and optional functions) under the same index. This is a precondition of an open system and of exchangeability of the instruments.

The entries of the object directory are addressed by a 16-bit index. Each index can be further subdivided by a sub-index.

Overview of objects

Index	Name	Description	*see page*
1000h	Device Type	indicates the device profile and the encoder type	*24*
1001h	Error Register	indicates error states of the encoder	*24*
1002h	Manufacturer Status Register	indicates the contents of the CAN bus-specific "TransmitErrorCounter" or "ReceiveErrorCounter", respectively	*24*
1003h	Pre-Defined Error Field	the object stores the 8 error states that have occurred last	*25*
1005h	COB ID SYNC message	setting of the COB ID of the SYNC object	*25*
1008h	Manufacturer Device Name	short designation of the device type	*26*
1009h	Manufacturer Hardware Version	hardware version of the encoder	*26*

Index	Name	Description	see page
100Ah	Manufacturer Software Version	software version of the encoder	26
1010h	Store Parameters	the object indicates non-volatile storage of parameters by the encoder with no user input	26
1011h	Restore Parameters	the object indicates that the encoder automatically loads parameters from the non-volatile memory	28
1014h	COB ID Emergency Object	COB ID of the Emergency object	28
1017h	Producer Heartbeat Time	setting of the cycle time of the heartbeat timer	29
1018h	Identity Objekt	contains the manufacturer number and device variant assigned by CiA	29
1200h	Server SDO Parameter	SDO parameter	30
1400h	Receive PDO1 Communication Parameter	receive PDO for asynchronous operating mode	30
1401h	Receive PDO2 Communication Parameter	receive PDO for synchronous operating mode	31
1600h	Receive PDO1 Mapping Parameter		31
1601h	Receive PDO2 Mapping Parameter		32
1800h	Transmit PDO1 Communication Parameter	transmit PDO for the asynchronous operation mode (timer-controlled)	32
1801h	Transmit PDO2 Communication Parameter	transmit PDO for the synchronous operation mode, including output of the position value via RTR	33
1A00h	Transmit PDO1 Mapping Parameter		34
1A01h	Transmit PDO2 Mapping Parameter		35
2001h	Manufacturer Offset	manufacturer-specific offset value (is added to the position value encoder-internally)	35
2002h	Zero encoder	set position value to value 0 (position value = 0 + Manufacturer offset + pre-set value)	36
2003h	Enable for zeroing	indicates whether zeroing via key actuation is enabled	36
2004h	Enable for incremental measurement	indicates whether setting the position value as an incremental measurement via key actuation is enabled	36
5F09h	External heartbeat timer	expected heartbeat cycle time	37
5F0Ah	Node-ID	Node ID, ! Change only active after re-initialization	37
5F10h	Target window	max. deviation from target value, if actual value within the window: target value achieved	37

Index	Name	Description	see page
5F11h	Decimal places	number of decimal places	*37*
5F12h	Display orientation and LED	0° or 180° function of the LEDs	*38*
5F13h	Display divisor		*38*
5F14h	Loop width	width of the loop	*38*
5F15h	Loop direction	direction from which travel to target value must be started	*39*
5F16h	Read target value	read current target value; write access only via PDO	*40*
5F18h	Trigger source of ext. heartbeat	signal which triggers external heartbeat	*40*
5F19h	Device status	is attached to position value in PDO	*40*
5F1Bh	Free factor	resolution with free factor	*41*
6000h	Operating Parameters	Setting the counting direction and scaling function	*42*
6002h	Total measuring range in measuring units	parameterization of the total measuring range of the encoder	*43*
6003h	Preset Value	parameterization of a pre-set (calibration) value	*43*
6004h	Position Value	position value (offset with pre-set and manufac-turer offset value)	*43*
6005h	Measuring step settings	measuring increments (resolution)	*44*
6200h	Cycle Timer PDO1	value in ms, identical with object 1800h, sub-index 5	*45*
6500h	Operating Status	indicates the countig direction and scaling func-tion currently set	*45*
6501h	Resolution	indicates the maximum resolution in increments	*45*
6502h	Number of distin-guishable Revolutions	indicates the maximum possible number of revo-lutions (1 revolution for linear systems)	*46*
6503h	Alarms	indication of error states	*46*
6504h	Supported Alarms	indicates which alarm messages are supported	*46*
6505h	Warnings	indication of warnings	*47*
6506h	Supported Warnings	indicates which warnings are supported	*47*
6507h	Profile and Software Version	indicates the version number of the device profile used and the version number of the encoder’s firmware	*47*
6508h	Operating Time	outputs the value FFFFFFFFh (function is not supported)	*48*
6509h	Offset Value	corresponds with the encoder’s zero point value	*48*
650Ah	Module Identification	device-specific parameters (Manufacturer offset, Manufacturer min position value, Manufacturer max position value) can be represented via sub-indexes	*48*
650Bh	Serial Number	outputs the value FFFFFFFFh (function is not supported)	*49*

Detailed description of objects

Object 1000h (Device Type)

Sub-index	**00h**			
Description	Information on device type and device profile			
Access	ro			
Data type	UNSIGNED 32			
EEPROM	no			
Default	00080196h			
Data content	Device profile number		Encoder type	
	Byte 0	Byte 1	Byte 2	Byte 3
	96h	01h	08h	00h

0196h (= 406): CANopen Device Profile for Encoders, Version 3.01

0008h: Absolute Linear Encoder

Object 1001h (Error Register)

Sub-index	**00h**	
Description	Device errors occurring are indicated here	
Access	ro	
Data type	UNSIGNED 8	
EEPROM	no	
Default	0	
Data content	Bit	Meaning
	0	set bit indicates the occurrence of any error condition
	4	set bit indicates communication error on the CAN bus (Acknowledgement-, Form-, CRC- and Stuffbit)
	7	Battery status or sensor error
	1-3, 5, 6	not used

Object 1002h (Manufacturer Status Register)

Sub-index	**00h**			
Description	The counts of the registers "Transmit Error Counter" and "Receive Error Counter" can be read via this object. The contents of these registers provide information on the transmit faults present at the mounting site of the encoder.			
Access	ro			
Data type	UNSIGNED 32			
EEPROM	no			
Default	0			
Data content	Byte 0	Byte 1	Byte 2	Byte 3
	Receive Error Counter	Transmit Error Counter	-	-

For details on the above-mentioned counters refer to the relevant CAN bus publications.

Object 1003h (Pre-defined Error Field)

- the object stores the 8 error states that have occurred last.
- the entry under sub-index 0 indicates the number of errors saved.
- each newly error state added is stored under sub-index 1. Previous error messages "slip" in their position by one digit.
- the whole error list is deleted by writing the value 0 at sub-index 0.
- the entries in the error list have the format described in, "Emergency Service".

Sub-index	**00h**
Description	number of the error messages stored
Access	rw (writable in the "Pre-Operational" and "Operational" states)
Data type	UNSIGNED 8
EEPROM	no
Default	0
Value range	0 – 8

Sub-index	**01h ... 08h**
Description	error messages that occurred
Access	ro
Data type	UNSIGNED 32
EEPROM	no
Default	0

Object 1005h (COB ID SYNC message)

Sub-index	**00h**	
Description	Defines the COB ID of the synchronization object (SYNC)	
Access	rw (writable in the "Pre-Operational" state only)	
Data type	UNSIGNED 32	
EEPROM	yes	
Default	80h	
Data content	Bit 31	not defined
	Bit 30	0: encoder generates no SYNC message 1: encodes generates SYNC messages
	Bit 29	0: 11bits identifier (CAN 2.0A) 1: 29bits identifier (CAN 2.0B) ! not supported !
	Bit 28 ... 11	0: if bit 29 = 0
	Bit 10 ... 0	X: bits 10 – 0 of the SYNC-COB-ID

Object 1008h (Manufacturer Device Name)

Sub-index	**00h**			
Description	short encoder designation in ASCII			
Access	const			
Data type	Visible_String			
EEPROM	no			
Default	AP4S			
Data content	Byte 0	Byte 1	Byte 2	Byte 3
	41h ('A')	50h ('P')	34h ('4')	53h ('S')

Object 1009h (Manufacturer Hardware Version)

Sub-index	**00h**			
Description	hardware version in ASCII			
Access	const			
Data type	Visible_String			
EEPROM	no			
Default	"V100"			
Data content	Byte 0	Byte 1	Byte 2	Byte 3
	56h ('V')	31h ('1')	30h ('0')	30h ('0')

Object 100Ah (Manufacturer Software Version)

Sub-index	**00h**			
Description	software version in ASCII			
Access	const			
Data type	Visible_String			
EEPROM	no			
Default	"V101"			
Data content	Byte 0	Byte 1	Byte 2	Byte 3
	56h ('V')	31h ('1')	30h ('0')	31h ('1')

Object 1010h (Store Parameters)

This object serves only for information that the encoder automatically stores specific parameters in the EEPROM. The "Store Parameter" command is not required for parameter storage!

Sub-index	**00h**
Description	describes the number of entries present in sub-index 1
Access	ro
Data type	UNSIGNED 8
EEPROM	no
Default	1h

Sub-index	**01h**	
Description	describes the behavior of the encoder, how parameters are stored in the EEPROM	
Access	ro	
Data type	UNSIGNED 32	
EEPROM	no	
Default	2h	
Data content	Bit 31-2	0
	Bit 1	0: encoder does not store parameters automatically 1: encoder stores parameters automatically following write access to relevant object
	Bit 0	0: encoder does not store parameter by comman 1: encoder stores parameter by command

The following table represents the parameters, which are stored non-volatilely in the EEPROM:

Objekt	Sub-index	Description	Default value
1005h	0h	SYNC-ID	80h
1014h	0h	EMCY-ID	80h + Node-ID
1017h	0h	Producer Heartbeat Time	0h
1400h	1h	RPDO1-ID	40000200h + Node-ID
1401h	1h	RPDO2-ID	40000300h + Node-ID
1800h	1h	TPDO1-ID	40000180h + Node-ID
1800h	5h	PDO1 Event Timer	0h
1801h	1h	PDO2-ID	80000280h + Node-ID
1801h	2h	PDO2 Transmission Type	1h
2001h	0h	Manufacturer Offset	0h
2003h	0h	Enable for zeroing	1h
2004h	0h	Enable for incremental measurement	1h
5F09h	0h	External heartbeat timer	0h
5F0Ah	0h	Node-ID	1h
5F10h	0h	Target window	5h
5F11h	0h	Decimal places	0h
5F12h	0h	Display orientation / LED	300h
5F13h	0h	Display divisor	0h
5F14h	0h	Loop reversal point	0h
5F15h	0h	Loop direction	0h
5F18h	0h	External heartbeat source	0h
5F1Bh	0h	Free factor	0h
6000h	0h	Operating Status	0h
6002h	0h	Total measurement range	+/-65535999
6003h	0h	Preset value	0h
6005h	0h	Resolution	0h
6200h	0h	PDO1 Event Timer	see object 1800-5

Object 1011h (Load Default Parameters)

This object serves for setting the encoder to its default values. To be protected against unintended loading of the default values, the string "load" must be written in sub-index 1h:

COB ID	Command	Index Low	Index High	Sub-index	Data 0 (LSB)	Data 1	Data 2	Data 3 (MSB)
600h+ Node-ID	23h	11h	10h	01h	'l' (6Ch)	'o' (6Fh)	'a' (61h)	'd' (64h)

The write access to the respective sub-indexes results in the values represented below:

Sub-index	**00h**
Description	indicates the largest supported sub-index
Access	ro
Data type	UNSIGNED 8
EEPROM	no
Default	1h

Sub-index	**01h**	
Description	All default values are loaded (except Node-ID and baud rate)	
Access	rw (writable in the "Pre-Operational" and "Operational" states)	
Data type	UNSIGNED 32	
EEPROM	no	
Default	1h	
Data content	Bit 31-1	0
	Bit 0	0: Encoder does not permit loading of default parameters. 1: Encoder permits loading of default parameters.

Object 1014h (COB ID Emergency Object)

Sub-index	**00h**	
Description	Defines the COB ID of the Emergency object (EMCY)	
Access	rw (writable in the "Pre-Operational" state only)	
Data type	UNSIGNED 32	
EEPROM	yes	
Default	80h + Node-ID	
Data content	Bit 31	0: EMCY object exists / is valid 1: EMCY object does not exists / is invalid
	Bit 30	always 0
	Bit 29	0: 11bits identifier (CAN 2.0A) 1: 29bits identifier (CAN 2.0B) ! not supported !
	Bit 28 ... 11	0: if bit 29 = 0
	Bit 10 ... 0	X: bits 10 – 0 of the EMCY-COB ID

Object 1017h (Producer Heartbeat Time)

Sub-index	**00h**
Description	defines the cycle time of the heartbeat monitoring service
Access	rw (writable in the "Pre-Operational" and "Operational" states)
Data type	UNSIGNED 16
EEPROM	yes
Default	0h
Value range	10 ... 65535 (Ah ... FFFFh); the numerical value corresponds to a multiple of 1 ms. Value 0 disables the service. Values in the range of 1 ... 9 trigger an error message!

Object 1018h (Identity Object)

Sub-index	**00h**
Description	number of entries
Access	ro
Data type	UNSIGNED 8
EEPROM	no
Default	2h

Sub-index	**01h**
Description	the manufacturer identification number (vendor ID) for the company SIKO GmbH allocated by the CiA (see www.can-cia.org)
Access	ro
Data type	UNSIGNED 32
EEPROM	no
Default	195h

Sub-index	**02h**			
Description	indicates the display version ASCII-coded			
Access	ro			
Data type	UNSIGNED 32			
EEPROM	no			
Default	"CAN"			
Data content	Byte 0	Byte 1	Byte 2	Byte 3
	43h ('C')	41h ('A')	4Eh ('N')	00h

Object 1200h (Server SDO Parameter)

Sub-index	00h
Description	largest sub-index supported
Access	ro
Data type	UNSIGNED 8
EEPROM	no
Default	2h

Sub-index	01h
Description	COB ID Client -> Server (rx)
Access	ro
Data type	UNSIGNED 32
EEPROM	yes
Default	00000600h + Node-ID

Sub-index	02h
Description	COB ID Server -> Client (tx)
Access	ro
Data type	UNSIGNED 8
EEPROM	no
Default	00000580h + Node-ID

Object 1400h (Receive PDO1 parameter, asynchronous operational mode)

Sub-index	00h
Description	largest sub-index supported
Access	ro
Data type	UNSIGNED 8
EEPROM	no
Default	2h

Sub-index	01h	
Description	COB ID of RPDO1	
Access	rw	
Data type	UNSIGNED 32	
EEPROM	yes	
Default	40000200h + Node-ID	Bit30 = 1: RTR for this PDO not released, bit is always set

Sub-index	**02h**
Description	Transmission Type
Access	ro
Data type	UNSIGNED 8
EEPROM	no
Default	FFh (255) cannot be changed, update with PDO receipt

Object 1401h (Receive PDO2 parameter, synchronous operational mode)

Sub-index	**00h**
Description	largest sub-index supported
Access	ro
Data type	UNSIGNED 8
EEPROM	no
Default	2h

Sub-index	**01h**
Description	COB ID of RPDO2
Access	rw
Data type	UNSIGNED 32
EEPROM	yes
Default	40000300h + Node-ID Bit30 = 1: RTR for this PDO not released, bit is always set

Sub-index	**02h**
Description	Transmission Type
Access	ro
Data type	UNSIGNED 8
EEPROM	no
Default	FFh (255) cannot be changed, update with PDO receipt

Object 1600h (Receive PDO1 Mapping Parameter)

Sub-index	**00h**
Description	number of objects mapped
Access	const
Data type	UNSIGNED 8
EEPROM	no
Default	1h

Sub-index	01h
Description	Describes the content of the PDO1 message
Access	const
Data type	UNSIGNED 32
EEPROM	no
Default	5F160020h (object 5F16h, 32bit)

Object 1601h (Receive PDO2 Mapping Parameter)

Sub-index	00h
Description	number of objects mapped
Access	const
Data type	UNSIGNED 8
EEPROM	no
Default	1h

Sub-index	01h
Description	Describes the content of the PDO2 message
Access	const
Data type	UNSIGNED 32
EEPROM	no
Default	5F160020h (object 5F16h, 32bit)

Object 1800h (Transmit PDO1 parameter, asynchronous operation mode)

Sub-index	00h
Description	largest sub-index supported
Access	ro
Data type	UNSIGNED 8
EEPROM	no
Default	5h

Sub-index	01h
Description	COB ID of PDO1
Access	rw (writable in the "Pre-Operational" state only)
Data type	UNSIGNED 32
EEPROM	yes
Default	40000180h + Node-ID Bit30 = 1: RTR for this PDO not released, bit is always set

Sub-index	**02h**
Description	Transmission Type
Access	ro
Data type	UNSIGNED 8
EEPROM	no
Default	FEh (254) PDO has asynchronous characteristics (PDOs are sent depending on the "Event Timer"). This value cannot be changed!

Sub-index	**03h (is not used, access attempt generates error message)**

Sub-index	**04h (is not used, access attempt generates error message)**

Sub-index	**05h**
Description	Event Timer
Access	rw (writable in the "Pre-Operational" state only)
Data type	UNSIGNED 16
EEPROM	yes
Value range	0 ... 65535 (1h ... FFFFh); the numerical value corresponds to a multiple of 1 ms. The service is disabled by writing the value 0. The content of this object is identical with object 6200h.

Object 1801h (Transmit PDO2 parameter, synchronous operation mode)

Sub-index	**00h**
Description	largest sub-index supported
Access	ro
Datentyp	UNSIGNED 8
EEPROM	no
Default	5h

Sub-index	**01h**
Description	COB ID of PDO2
Access	rw (writable in the "Pre-Operational" state only)
Data type	UNSIGNED 32
EEPROM	yes
Default	00000280h + Node-ID

Sub-index	**02h**
Description	Transmission Type
Access	rw (writable in the "Pre-Operational" state only)
Data type	UNSIGNED 8
EEPROM	yes
Default	1h PDO has synchronous characteristics
Value range	1h … F0h (240) the PDO will be sent following every SYNC command FDh (253): encoder responds to RTR request

Sub-index	**03h (is not used, access attempt generates error message)**

Sub-index	**04h (is not used, access attempt generates error message)**

Sub-index	**05h (is not used, access attempt generates error message)**

Object 1A00h (Transmit PDO1 Mapping Parameter)

Sub-index	**00h**
Description	number of objects mapped
Access	const
Data type	UNSIGNED 8
EEPROM	no
Default	2h

Sub-index	**01h**
Description	Describes the 1st portion of the PDO1 message (data bytes 0 to 3)
Access	const
Data type	UNSIGNED 32
EEPROM	no
Default	60040020h (object 6004h, 32bit) position value

Sub-index	**02h**
Description	Describes the 2nd portion of the PDO1 message (data byte 4)
Access	const
Data type	UNSIGNED 8
EEPROM	no
Default	5F190008h (object 5F19h, 8bit) AP04S status

Object 1A01h (Transmit PDO2 Mapping Parameter)

Sub-index	00h
Description	number of objects mapped
Access	const
Data type	UNSIGNED 8
EEPROM	no
Default	2h

Sub-index	01h
Description	Describes the 1st portion of the PDO2 message (data bytes 0 to 3)
Access	const
Data type	UNSIGNED 32
EEPROM	no
Default	60040020h (object 6004h, 32bit) position value

Sub-index	02h
Description	Describes the 2nd portion of the PDO2 message (data byte 4)
Access	const
Data type	UNSIGNED 8
EEPROM	no
Default	5F190008h (object 5F19h, 8bit) AP04S status

Object 2001h (Manufacturer Offset)

Sub-index	00h
Description	The offset enables the shifting of a scaled value range. The offset value is added to the position value in the encoder. Positive as well as negative values are permitted. Position value = measured value + calibration value + offset value
Access	rw
Data type	SIGNED 32
EEPROM	yes
Default	0h
Value range	The minimum or maximum values to be entered depend on the values entered in object 650Ah, sub-index 2 or sub-index 3, respectively. The latter depend on the parameterized value of the total of measuring steps: lower_limit = - 1/2 total of measuring steps = -65536000, upper_limit = 1/2 total of measuring steps – 1 = 65535999 -65536000 < offset < 65536999

Object 2002h (Zeroing of encoder value)

Sub-index	**00h**
Description	The object enables "zeroing" of the measured value. Position value = measured value + calibration value + offset value
Access	rw (writable in the "Pre-Operational" and "Operational" states)
Data type	UNSIGNED 8
EEPROM	no
Default	no
Value range	0 ... 1; writing the value 1 on sub-index 0 sets the position value to 0. After renewed zeroing the figure 1 will be output in case of read access.

Example:

Measured value = 214 calibration value = 400, offset value = 0,
results in position value = 614 (see object 6004h)

COB ID	Com-mand	Index Low	Index High	Sub-index	Data 0 (LSB)	Data 1	Data 2	Data 3 (MSB)
600h+ Node-ID	23h	02h	20h	00h	01h	00h	00h	00h

Measured value = 0
results in position value = 400

This function does not depend on zeroing enable via keyboard (object 2003h)

Object 2003h (Enable zeroing of encoder value via keyboard)

Sub-index	**00h**
Description	Zeroing via ✱ key is enabled with this object.
Access	rw (writable in the "Pre-Operational" and "Operational" states)
Data type	UNSIGNED 8
EEPROM	yes
Default	1
Value range	0: Zeroing via ✱ key disabled 1: Zeroing via ✱ key enabled

Object 2004h (Incremental measurement enable)

Sub-index	**00h**
Description	Switching on incremental measurement function via ⬆ key is enabled with this object.
Access	rw (writable in the "Pre-Operational" and "Operational" states)
Data type	UNSIGNED 8
EEPROM	yes
Default	1
Value range	0: Incremental measurement function via ⬆ key disabled 1: Incremental measurement function via ⬆ key enabled

Object 5F09h (External Heartbeat Timer)

Sub-index	**00h**
Description	If a value > 0 is entered here, the AP04S will expect an event to occur in this interval (see object 5F18h). If no such event occurs, the AP04S will change to the "Pre-operational" state.
Access	rw (writable in the "Pre-Operational" and "Operational" states)
Data type	UNSIGNED 16
EEPROM	yes
Default	0h
Value range	0 ... 65535 (0h ... FFFFh); the numerical value corresponds to a multiple of 1 ms. The function is disabled by writing the value 0.

Object 5F0Ah (Node-ID)

Sub-index	**00h**
Description	Node-ID of AP04S
Access	rw (writable in the "Preoperational" and "Operational" states) The ID set here will become valid only after re-initialization of communication or power-up.
Data type	UNSIGNED 8
EEPROM	yes
Default	0h
Value range	1 ... 127 (1h ... 7Fh)

Object 5F10h (Target window)

Sub-index	**00h**
Description	max. valid deviation from target value, if actual value is within the window: target value achieved
Access	rw (writable in the "Pre-Operational" and "Operational" states)
Data type	UNSIGNED 32
EEPROM	yes
Default	5h
Value range	0 ... 4.294.967.296 (0h … FFFFFFFFh)

Object 5F11h (Decimal places)

Sub-index	**00h**
Description	Number of decimal places
Access	rw (writable in the "Pre-Operational" and "Operational" states)
Data type	UNSIGNED 8
EEPROM	yes
Default	0h
Value range	0 ... 4 (0h … 4h)

Object 5F12h (Display orientation and LED)

Sub-index	**00h**			
Description	Display orientation 0° or 180° additionally LED functionality			
Access	rw (writable in the "Pre-Operational" and "Operational" states)			
Data type	UNSIGNED 32			
EEPROM	Basic functions yes			
Default	0h			
Value range	0; 14516 (38B4h)			
Data content	Reserved for future use		LED	Display
	Byte 3	Byte 2	Byte 1	Byte 0
	00h	00h	0 … 56	0 or 180 (B4h)

Coding	Byte 0: Display	0h: 0° B4h: 180°
	Byte 1: LED	bit 0 = 0: LED green OFF bit 0 = 1: LED green ON when position in target window bit 1 = 0: LED red OFF bit 1 = 1: LED red ON when position outside target window bit 3 = 1: LEDs blink when ON bit 4 = 1: LED green ON independent of target window bit 5 = 1: LED red ON independent of target window Only bits 0 … 3 are saved non-volatilely

Object 5F13h (Display divisor)

Sub-index	**00h**
Description	Display divisor (ADI)
Access	rw (writable in the "Pre-Operational" and "Operational" states)
Data type	UNSIGNED 8
EEPROM	yes
Default	1h
Value range	0 … 3 (0h … 3h) 0: Indication of the position value: "10000" 1: Indication of the position value: "1000" 2: Indication of the position value: "100" 3: Indication of the position value: "10"

Object 5F14h (Loop width)

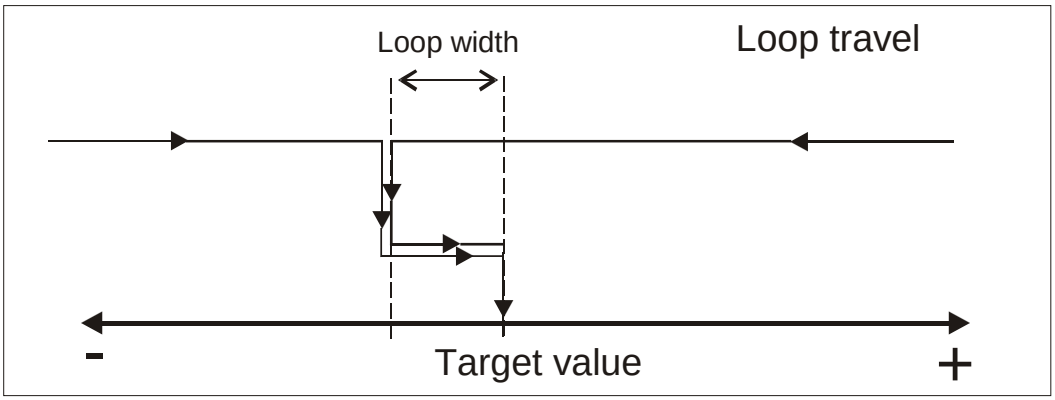
Sub-index	**00h**
Description	Loop width; the target value will be exceeded by this value in case of loop travel.
Access	rw (writable in the "Pre-Operational" and "Operational" states)
Data type	UNSIGNED 32
EEPROM	yes
Default	0h
Value range	0 ... 4.294.967.296 (0h … FFFFFFFFh)

Description of loop travel, see object 5F15h loop travel.

Object 5F15h (Loop direction)

Sub-index	**00h**
Description	Loop direction; travelling to the target value is always in this direction.
Access	rw (writable in the "Pre-Operational" and "Operational" states)
Data type	UNSIGNED 32
EEPROM	yes
Default	524944h
Value range	0h ... 524944h 0h: direct (write) 2Bh: = ASCII "+" in positive counting direction 2Dh: = ASCII "-" in negative counting direction 524944h: =ASCII "DIR" direct (response to read)

If the AP04S is operated on a spindle, then the spindle play can be compensated by means of loop positioning.
In this case, travelling to the target value is always from the same direction.



Example:
Counting direction = "POS" i. e., the position value increases when the sensor moves towards the sensor cable (object 6000h bit 0 = 0)
Loop width = 100 (Objekt 5F14h = 100)
The direction from which every target position shall be driven to is: "POS" (Objekt 5F15h = "+")
current position value = 1000

- Case 1 ➡ new target value = 1500

  direct travel to target position

- Case 2 ➡ new target value = 500

  The positioning aid (arrows) of AP04S requires that the target position (500) will be exceeded by the loop width (object 5F14h). Upon reaching the loop target position (400 = target position – loop width), the positioning arrows will be reversed and travel to the target position 500 is enabled.

Object 5F16h (Read target value)

Sub-index	**00h**
Description	Read target value
Access	rw (writable in the "Pre-Operational" and "Operational" states) write access only via PDO
Data type	UNSIGNED 32
EEPROM	no
Default	0h
Value range	0 ... 4.294.967.296 (0h … FFFFFFFFh)

Any attempt at writing on this object via SDO will result in an error message (error code: 06010000h).

Object 5F18h (External Heartbeat source)

Sub-index	**00h**
Description	Event triggering an external heartbeat timer (object 5F09h)
Access	rw (writable in the "Pre-Operational" and "Operational" states)
Data type	UNSIGNED 8
EEPROM	yes
Default	0h
Value range	0 ... 1 0: Timer is triggered when receiving a PDO (target value) 1: Timer is triggered when receiving a sync

Object 5F19h (AP04S status)

Sub-index	**00h**
Description	The status byte informs about the current state of AP04S.
Access	ro (readable in the "Pre-Operational" and "Operational" PDO states only)
Data type	UNSIGNED 8
EEPROM	yes
Default	1h
Value range	1h ... EEh

The bits of the status byte have the following meaning:

Bit	Value = 0	Value = 1
0	Not IN-POS	IN-POS
1	ACT. ≤ TARG	ACT. > TARG
2	Battery ok	Battery warning
3	increm. meas. = 0	increm. meas. = set
4	">" off	">" on
5	"<" off	"<" on
6	Magnetic strip - sensor distance ok	error: Magnetic strip - sensor distance
7	Sensor connected	error: no sensor

Any attempt at writing on this object will result in an error message (error code: 06010000h).

Object 5F1Bh (Free factor for resolution)

Sub-index	**00h**
Description	Free factor for resolution
Access	rw (writable in the "Pre-Operational" and "Operational" states)
Data type	UNSIGNED 16
EEPROM	yes
Default	10000
Value range	1 … 30000

On principle, the AP04S supports the resolution steps indicated with Object 6005h. A (free) factor must be set in if resolutions differing from these increments are required or if the AP04S is used in a rotating measuring system.

Internally, the display functions with a resolution of 0.01 mm. Therefore, 100 counter increments correspond to 1 mm.

These values also determine the decimal point and the display divisor (ADI).

If a free factor has been programmed, this factor will be applied and ADI as well as DEZ must be programmed additionally. If the display is reconfigured afterwards and a fixed resolution step set, the free factor and ADI will continue to be stored and can be reactivated via configuration of the device, but they will no longer be applicable nor used for determination of the position.

Calculation of the free factor
Calculation of the factor to be set is explained in the examples below.

Example 1:
Display of 2.0 mm / spindle revolution desired.
Scale used: pole wheel with 36 poles of each 5 mm.
Display = measured value x factor

1 revolution = 36 poles x 5 mm = 180 mm corresponds to 18000 counter increments.
Display: 20 increments / revolution = 20 incr. / 18000 = 0.0011111
Factor = 0.0011111
Display = measured value x 0.0011111

The transfer value for the free factor is interpreted as fixed comma value with 1 digit before the comma and 4 digits after the comma. In order to achieve optimum accuracy, the factor is multiplied by 10 digits until 4 digits after the comma containing information are obtained.

Factor = 0.0011111 x 10 x 10 = 0.1111 => transfer value 01111dec = 457hex
exponent = 2

The resulting decimal power (exponent) is set with the parameter ADI = 2. The decimal point must be inserted with the parameter decimal place = 1.

Example 2:
AP04S with "double carriage": Spindle whose thread runs in the opposite direction and 2 carriages, e. g. 5 cm travel distance of one carriage (sensor) result in 10 cm travel distance between both carriages,
Display in 1.00 mm desired
Scale used: MB500

Factor = 2.0 => transfer value = 20000 = 4E20hex
Factor = 2.0 => transfer value = 20000 = 4E20hex
ADI = 0
DEZ = 2

Example 3:
Display in 0.1° desired
Scale used: Pole wheel with 64 poles of each 5 mm.
1 revolution (360°) = 64 poles x 5 mm = 320 mm corresponds to 32000 counter increments
Display: 360.0° / revolution = 3600 / 32000 = 1,1250
Factor = 1.1250 => Transfer value = 11250 = 2BF2hex
ADI = 0
DEZ = 1

Example 4:
Display in 0.01° desired
Scale used: Pole wheel with 188 poles of each 5 mm.
1 revolution (360°) = 188 poles x 5 mm = 940 mm corresponds to 94000 counter increments
Display: 36000 / revolution = 36000 / 94000 = 0.3829787
Factor = 0.3829787 => transfer value = 03830 = EF6hex
ADI = 0
DEZ = 2

Object 6000h (Operating Parameters)

Sub-index	**00h**				
Description	This object influences the encoder's sense of rotation and the scaling function.				
Access	rw (writable in the "Pre-Operational" and "Operational" states)				
Data type	UNSIGNED 16				
EEPROM	yes				
Default	0h				
Bit definition		Bit 14 ... Bit 3	Bit 3	Bit 2	Bit 1 … Bit 0
	Function	not used	counting direction	Scaling	not used
	Bit = 0	-	pos	disabled	-
	Bit = 1	-	neg	enabled	-

Explanation of the functions:

Counting direction pos: ascending position values with sensor movement towards the sensor cable.

Counting direction neg: ascending position values with sensor movement away from the sensor cable.

Scaling disabled: The encoder works with its set resolution. Any attempt to change it by means of object 6005h will be answered with an error message.

Scaling enabled: The resolution (object 6005h) can be parameterized.

Object 6002h (Total Measuring Range)

Sub-index	**00h**
Description	Number of measurement steps with set resolution
Access	ro (readable in the "Pre-Operational" and "Operational" states)
Data type	UNSIGNED 32
EEPROM	no
Default	131071999
Value range	51603 … 131071999 (C993h … 7CFFFFFh)

Object 6003h (Preset value)

Sub-index	**00h**
Description	The position value of the encoder is set to this preset (calibration) value when zeroing. Position value = measured value + calibration value + offset value see object 6004h
Access	rw (writable in the "Pre-Operational" and "Operational" states)
Data type	SIGNED 32
EEPROM	yes
Default	0h
Value range	0 ... 4.294.967.296 (0h … FFFFFFFFh)

Object 6004h (Position value)

Sub-index	**00h**
Description	This object provides the position value of the encoder offset with the scaling factors, preset and Manufacturer Offset.
Access	ro
Data type	SIGNED 32
EEPROM	no

The position value of the AP04S is calculated by using the following formula:

*Position value = (encoder value - encoder zeroing value)*RF + preset value + Manufacturer Offset*

Encoder value:	absolute value sensed by the encoder sensor system,
Encoder zeroing value:	absolute value at the time of zeroing,
RF:	Calculation (scaling) factor, Ex.: RF = 1 with display resolution 0.01 mm RF = 0.01 with resolution 1 mm
Preset value:	see Object 6300h
Manufacturer Offset	see Object 2100h

With the AP04S, the total measuring range is subdivided into a negative and positive value range:

-1/2 total measuring range ... 0 ... +1/2 (total measuring range – 1)

Therefore, the representation of the position value is in the 2-complement format in a signed 32 bits number.

Object 6005h (Resolution)

Sub-index	**00h**
Description	Contains the number of the highest sub-index
Access	ro
Data type	UNSIGNED 8
EEPROM	no
Default	1h

Sub-index	**01h**
Description	This parameter sets the desired resolution. After DS406 it must be indicated in multiples of nm
Access	rw (writable in the "Pre-Operational" and "Operational" states)
Data type	UNSIGNED 32
EEPROM	yes
Default	0
Value range	10000 … 25400000
Supported values:	10000: Display in 0.01 mm 100000: Display in 0.1 mm 1000000: Display in 1.0 mm 10000000: Display in 10 mm 25400: Display in 0.001 inch 254000: Display in 0.01 inch 2540000: Display in 0.1 inch 25400000: Display in 1 inch

If resolutions other than the above-named are to be supported, the parameter Free Factor, Object 5F1Bh must be used.

Object 6200h (Cycle Timer)

Sub-index	**00h**
Description	Defines the cycle time with which the PDO1 is output. The value is fixed-linked (identical) with the value indicated under object 1800h, sub-index 5. The timer-controlled output is activated as soon as a cycle time was parameterized within the value range and the encoder switched over to the Operational Mode.
Access	rw (writable in the "Pre-Operational" and "Operational" states)
Data type	UNSIGNED 16
EEPROM	yes
Default	0h
Value range	0: Cycle timer is disabled, 1 ... 65535: cycle time in ms

Object 6500h (Operating Status)

Sub-index	**00h**
Description	The object indicates the settings programmed with object 6000h (counting direction, scaling enable).
Access	ro
Data type	UNSIGNED 16
EEPROM	counting direction yes; scaling enable no
Default	0
Bit definition	see object 6000h

Object 6501h (Resolution)

Sub-index	**00h**
Description	The object indicates the maximum possible encoder resolution in µm.
Access	ro
Data type	UNSIGNED 32
EEPROM	no
Default	10000 (2710h)

Object 6502h (Number of distinguishable revolutions)

Sub-index	**00h**
Description	The object indicates the maximum possible number of encoder revolutions. (with linear systems: 1)
Access	ro
Data type	UNSIGNED 16
EEPROM	no
Default	1

Object 6503h (Alarms)

Sub-index	**00h**
Description	In addition to the errors reported via the emergency messages, this object provides further, encoder-specific error messages. In the case of an error, the associated bit is set to 1.
Access	ro
Data type	UNSIGNED 16
EEPROM	no
Default	0h

Bitdefinition:

Bit	Function	Value = 0	Value = 1
0	position error	no error	position value invalid
1 … 11	not used	-	-
12	battery warning	battery voltage OK	battery voltage near lowest tolerable value
13	battery error	battery OK or still in tolerable range	battery discharged
14 … 15	not used		

Object 6504h (Supported Alarms)

Sub-index	**00h**
Description	The object indicates which alarm messages are supported. The relevant bits are set.
Access	ro
Data type	UNSIGNED 16
EEPROM	no
Default	3001h

Bit 0: position error

Bit 12: battery warning

Bit 13: battery alarm

Object 6505h (Warnings)

Sub-index	00h
Description	Warnings indicate that tolerances of internal encoder parameters have been exceeded. However, unlike with alarm messages, the position value can be valid in case of a warning.
Access	ro
Data type	UNSIGNED 16
EEPROM	no
Default	0h

Bit definition:

Bit	Function	Value = 0	Value = 1
0 .. 3	not used	-	-
4	battery warning	battery voltage OK	battery voltage near lowest tolerable value
5 ... 15	not used	-	-

Object 6506h (Supported Warnings)

Sub-index	00h
Description	The object indicates which warnings are supported.
Access	ro
Data type	UNSIGNED 16
EEPROM	no
Default	0010h

Bit 4: Battery warning is supported

Object 6507h (Profile and Software Version)

Sub-index	00h
Description	The object indicates the encoder profile used (CANopen Device profile for encoders) and the version number of the firmware state.
Access	ro
Data type	UNSIGNED 32
EEPROM	no
Default	00650301h

Data content:

Firmware Version		Profile Version	
Byte 3 (High)	**Byte 2 (Low)**	**Byte 1 (High)**	**Byte 0 (Low)**
00h	65h	03h	01h

Object 6508h (Operating Time)

Sub-index	**00h**
Description	Operation time counter (not implemented in the AP04S)
Access	ro
Data type	UNSIGNED 32
EEPROM	no
Default	FFFFFFFFh (shows that the function is not supported)

Object 6509h (Encoder Zeroing Value)

Sub-index	**00h**
Description	The difference between encoder value and the position value scaled and offset with preset and/or Manufacturer Offset is output via this object.
Access	ro
Data type	SIGNED 32
EEPROM	yes

$$\textit{Encoder zeroing value} = \textit{encoder value} - \frac{(\textit{position value} - \textit{preset value} - \textit{manufacturer offset}}{\textit{Scaling factor}}$$

Object 650Ah (Module Identification)

The Manufacturer Offset value (sub-index 1), the smallest (sub-index 2) and the largest (sub-index 3) position value can be read out via this object.

Sub-index	**00h**
Description	contains the number of additional sub-indexes.
Access	ro
Data type	UNSIGNED 8
EEPROM	no
Default	3h

Sub-index	01h
Description	manufacturer-specific offset value (is added to the position value) see object 2001h
Access	ro
Data type	SIGNED 32
EEPROM	yes
Default	0h

Sub-index	02h
Description	minimum transferable position value
Access	ro
Data type	SIGNED 32
EEPROM	no
Default	-65536000

Sub-index	03h
Description	maximum transferable position value
Access	ro
Data type	SIGNED 32
EEPROM	no
Default	65535999

Object 650Bh (Serial Number)

Sub-index	00h
Description	Provides the serial number of the encoder (not supported with the AP04S).
Access	ro
Data type	UNSIGNED 32
EEPROM	no
Default	FFFFFFFFh (Function is not implemented)