5-23 Position Sensor Object

Class Code: 23 hex

The Position Sensor Object models an absolute position sensor in a product. Behaviors in the object extend the basic position sensor capability to include zero offset, and position boundary checking (CAM switch).

The Position Sensor Object interface is to real position sensor hardware such as an absolute digital encoder, an analog resolver or other absolute position-input device.

5-23.1 Revision History

Since the initial release of this object class definition changes have been made that require a revision update of this object class. The table below represents the revision history.

Table 5-23.1 Revision History

Revision	Reason for Change
01	Initial release of this object class
02	Add new attributes

5-23.2 Class Attributes

Table 5-23.2 Position Sensor Object Class Attributes

Attr ID	Need in Implementation	Access Rule	Name	Data Type	Description of Attribute	Semantics of Values
1	Required	Get	Revision	UINT	Revision of this object	The current value assigned to this attribute is 02.
2 thru 7	These class attributes are optional and are described in Chapter 4 of this specification.					

5-23.3 Instance Attributes

Table 5-23.3 Position Sensor Object Instance Attributes

Attr ID	Need in Implem	Access Rule	NV	Name	Data Type	Description of Attribute	Semantics of Values
1	Optional	Get	NV	Number of Attributes	USINT	Number of attributes supported in this product	
2	Optional	Get	NV	Attribute List	Array of USINT	List of attributes supported in this product.	
3	Conditional [1]	Get	V	Position Value Unsigned	UDINT	Current position.	Physical position See Semantics Section
4	Optional	Get	V	CAM	BOOL	Virtual CAM switch value	0 = Off 1 = On
5	Optional	Set	V	Value Bit Resolution	USINT	Position sensor resolution.	See Semantics.
6	Optional	Set	V	Zero Offset	UDINT	Value attribute zero offset	See Semantics.
7	Optional	Set	V	CAM Low Limit	UDINT	Virtual CAM switch low limit.	The default is 0

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Attr ID	Need in Implem	Access Rule	NV	Name	Data Type	Description of Attribute	Semantics of Values
8	Optional	Set	V	CAM High Limit	UDINT	Virtual CAM switch high limit.	The default is 0
9	Optional	Set	V	Auto Zero	BOOL	Auto zero control.	Rising edge sets Zero Offset to Position Value
10	Conditional[1]	Get	V	Position Value Signed	DINT	Current position	The content is based upon 14, 15, 16, and 17.
11	Optional	Get	NV	Position Sensor Type	UINT	Specifies the device type	See Semantics section
12	Required	Set	NV	Direction Counting Toggle	BOOL	Defines the direction of increasing 'Position Value'	Default = 0. See semantics section
13	Optional	Set	NV	Commissioning Diagnostic Control	BOOL	Check encoder at encoder stand still	0 = OFF 1 = ON (Default)
14	Optional	Set	NV	Scaling Function Control	BOOL	*Physical resolution* span (attribute 42) is converted to a numerical value	0 = OFF 1 = ON (Default)
15	Optional	Set	NV	Position Format	ENGUNIT	Format of the position value of other attributes.	Supported units: counts(default) millimeter micron nanometer inch thousandths inch ten thousandths inch 0x0800-0x0FFF = vendor specific
16	Optional	Set	NV	Measuring Units per Span	UDINT	Number of distinguishable steps per one complete span. Less than or equal to *Physical Resolution Span* (attribute 42).	For rotary devices a span equals one revolution.
17	Optional	Set	NV	Total Measuring Range in Measuring Units	UDINT	Steps over the total measuring range. Only used for rotary encoders.	
18	Optional	Set	NV	Position Measuring Increment	UDINT	Specifies the smallest incremental change of the *Position Value Signed* or *Position Value Unsigned* attributes	Units depend on *Position Format* attribute. Default = 1.
19	Optional	Set	NV	Preset Value	DINT	Output position value is set to Preset Value.	See Semantics section
20	Optional	Set	NV	COS/delta	UDINT	Value for position change in COS mode.	See Semantics section
21	Optional	Get	V	Position State Register	BYTE	The state of software limit switch.	Bit 0: 1 = Out of Range Bit 1: 1 = Range overflow Bit 2: 1 = Range underflow
22	Optional	Set	NV	Position Low Limit	DINT	Low Limit Position	See Semantics section

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Attr ID	Need in Implem	Access Rule	NV	Name	Data Type	Description of Attribute	Semantics of Values
23	Optional	Set	NV	Position High Limit	DINT	High Limit Position When attribute 10 is greater than this value, the *Position State Register*, bit 1 shall be set to one (1).	See Semantics section
24	Optional	Get	V	Velocity Value	DINT	Current speed where the format of this value is defined in attributes 25 & 26.	Default is attribute 15 per second The meaning of the sign is affected by the value of attribute 12. See Semantics section
25	Conditional	~~/~~Set	NV	Velocity Format	ENGUINT	Format of the velocity attributes.	0x1f04 = counts (Steps) per second (default) See Semantics section
26	Conditional	Set	NV	Velocity Resolution	UDINT	Specifies the smallest incremental change of the *Velocity Value* attribute 24.	Units depend on Attr 25 Default = 1. See Semantics section
27	Conditional	Set	NV	Minimum Velocity Setpoint	DINT	Value for minimum velocity trigger threshold. Affects Min. Velocity Flag in status *Warning* Attribute 47	Default = 0x80000000. See Semantics section
28	Conditional	Set	NV	Maximum Velocity Setpoint	DINT	Value for maximum velocity trigger threshold. Affects Max. Velocity Flag in status *Warning* Attribute 47	See Semantics section Default = 0xEFFFFFFF. See Semantics section
29	Optional	Get	V	Acceleration Value	DINT	Current Acceleration where the format of this value is defined in attributes 30 & 31.	Default is *Velocity Value* attribute 24 per second^2 Positive value is acceleration, negative is deceleration. See Semantics section
30	Conditional	Set	NV	Acceleration Format	ENGUINT	Format of the Acceleration attributes.	0x1500 = m/s^2 (default) See Semantics section
31	Conditional	Set	NV	Acceleration Resolution	UDINT	Specifies the smallest incremental change of the *Acceleration Value*, attribute 29	Default = 1. See Semantics section
32	Conditional	Set	NV	Minimum Acceleration Setpoint	DINT	Value for minimum acceleration trigger threshold.	Default = 0x8000 0000. See Semantics section
33	Conditional	Set	NV	Maximum Acceleration Setpoint	DINT	Value for maximum acceleration trigger threshold.	Default = 0xEFFF FFFF . See Semantics section
34	Optional	Get	NV	Number of CAM Channels	USINT	Contains the number of independent cams	See Semantics section
35	Conditional	Get	V	CAM Channel State register	ARRAY of BOOL	Contains state of independent cam channels	Bit 0 = CAM_ 1 State ... Bit x = CAM x+1

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Attr ID	Need in Implem	Access Rule	NV	Name	Data Type	Description of Attribute	Semantics of Values
36	Conditional	Set	NV	CAM Channel Polarity Register	ARRAY of BOOL	Determines the polarity for each *Cam Channel State Register*	Bit 0 = CAM_ 1 Polarity ... Bit x = CAM x+1
37	Conditional	Set	NV	CAM Channel Enable Register	ARRAY of BOOL	Enables each independent cam channel where size of array is equal to *Number of CAM Channels* attribute.	Bit 0 = CAM_ 1 Enable ... Bit x = CAM x+1
38	Conditional	Set	NV	CAM Low Limit	ARRAY of DINT	Switch point for the lower limit where size of array is equal to *Number of CAM channels* attribute. When *Position Value Signed* is less than *CAM Low Limit* value, then *CAM Channel State Register* = 1.	
39	Conditional	Set	NV	CAM High Limit	ARRAY of DINT	Switch point for the higher limit where size of array is equal to "Number of CAM channel" *Number of CAM channels* attribute. *Position Value Signed* is greater than *CAM High Limit* value, then *CAM Channel State Register* = 1.	
40	Conditional	Set	NV	CAM Hysteresis	ARRAY of UINT	This value will be added to the *CAM High Limit* and subtracted from the *CAM Low Limit* when calculating the cam state.	See Semantics section
41	Optional	Get	V	Operating Status	BYTE	Encoder diagnostic operating status	See Semantics Section
42	Optional	Get	NV	Physical Resolution Span	UDINT	Number of distinguishable steps per one complete span.	For rotary devices, a span equals one revolution.
43	Optional	Get	NV	Number of Spans	UINT	This is equal to the number of turns when a rotary type device is used.	Default = 1.
44	Optional	Get	V	Alarms	WORD	Indicates a malfunction has occurred that could lead ~~in~~to an incorrect position value or require user intervention	See Semantics Section
45	Conditional	Get	NV	Supported Alarms	WORD	Information about supported *Alarms*	See Semantics Section
46	Conditional	Get	V	Alarm Fag	BOOL	Indicates that an alarm error occured.	See Semantics Section 0 = OK 1 = Alarm error

Attr ID	Need in Implem	Access Rule	NV	Name	Data Type	Description of Attribute	Semantics of Values
47	Optional	Get	V	Warnings	WORD	Internal parameters exceeded	See semantics section.
48	Conditional	Get	NV	Supported Warnings	WORD	Information about supported *Warnings*	See Semantics Section
49	Conditional	Get	V	Warning Flag	BOOL	Indicates that a-warning error occured	See Semantics Section 0 = OK 1 = Warning flag
50	Optional	Get	NV	Operating Time	UDINT	Stores operating time for the encoder in tenths of an hour	
51	Conditional	Get	NV	Offset Value	DINT	The Offset value is calculated by the preset function. Shift position value with the calculated value	See Semantics Section

1 One and only one of the attributes *Position Value Signed* or *Position Value Unsigned* shall be implemented depending on the application requirements.

5-23.4 Semantics

5-23.4.1 Position Value Unsigned - Attribute 3

This attribute represents the absolute position detected by the position sensor conditioned by the *Value Bit Resolution* and *Zero Offset* attributes. Refer to the following descriptions of the *Value Bit Resolution* and *Zero Offset* attributes for details.

5-23.4.2 Position Value Signed - Attribute 10

This attribute represents the absolute position detected by the position sensor. It is not conditioned by the *Value Bit Resolution* and *Zero Offset* attributes.

5-23.4.3 Value Bit Resolution – Attribute 5

This attribute specifies the number of significant bits used for the *Position Value Unsigned* (attribute 3). The raw value is shifted left or right to supply the indicated number of significant bits.

Table 5-23.4 Bit Resolution Attribute Value

Resolution	Value =
> Physical Resolution	(RawValue << (PhysicalResolution - Bit Resolution)) + ZeroOffset
< Physical Resolution	(RawValue >> (Bit Resolution - PhysicalResolution)) + ZeroOffset
= Physical Resolution	RawValue + ZeroOffset

Table 5-23.5 Example Bit Resolution Values

Raw Value	Resolution	Adjusted Val.	Notes
10 bit (0 to $3FF_{hex}$)	8	0 to FF_{hex}	Bit Resolution < Physical Resolution, surplus bits are discarded
6 bit (0 to $3F_{hex}$)	8	0 to FF_{hex}	Bit Resolution > Physical Resolution, missing bits are zero. Adjusted value will actually be 0 to FC_{hex} in multiples of 4
10 bit (0 to $3FF_{hex}$)	10	0 to $3FF_{hex}$	Bit Resolution = Physical Resolution, no conversion.

5-23.4.4 Zero Offset – Attribute 6

The Zero Offset Attribute adjusts the zero point of Value. Zero Offset is added to Value to adjust the zero point. The Zero Offset Attribute is applied *after* the *Value Bit Resolution* Attribute.

If the result of the addition exceeds the maximum specified by the Resolution attribute the overflow bits are discarded.

Table 5-23.6 Example Zero Offset Values

Adjusted Val.	Zero Offset	Resolution	Value
0	10	8	10
250	0	8	250
250	20	8	15 [1]
250	20	10	270
250	255	8	249 [2]

1 Value overflowed
2 Value underflowed

5-23.4.4.1 CAM, CAM Low Limit, CAM High Limit – Attributes 4, 7 and 8

The *CAM* attribute is a virtual CAM switch. The state of the *CAM* attribute is determined by the *CAM Low Limit, CAM High Limit* and *Position Value Unsigned* attributes. The *Position Value Unsigned* attribute is used after the *Value Bit Resolution* and *Zero Offset* attributes have been applied.

Table 5-23.7 CAM, CAM Low Limit & CAM High Limit Operation

CAM Low Limit	CAM is On (true, 1) if ...	CAM is Off (false, 0) if ...
> CAM High Limit	Value > CAM Low *or* Value < CAM High	Value < CAM Low *and* Value > CAM High
< CAM High Limit	Value > CAM Low *and* Value < CAM High	Value < CAM Low *or* Value > CAM High
= CAM High Limit	Never	Always

5-23.4.5 Auto Zero – Attribute 9

This attribute controls the auto-zero feature of the resolver. A rising edge (transition from 0 to 1) on this attribute adjusts the *Zero Offset* attribute to a value that results in the *Position Value Unsigned* attribute being zero.

If the *Zero Offset* attribute is implemented as non-volatile, the AutoZero command must store the new *Zero Offset* value.

5-23.4.6 Position Sensor Type – Attribute 11

Table 5-23.8 Attribute 11, Position Sensor Type Values

Value	Definition
00	Single Turn resolver (value if attribute is not supported)
01	Single-Turn absolute rotary encoder
02	Multi-Turn absolute rotary encoder
03	Single-Turn absolute rotary encoder with electronic turn count
04	Incremental rotary encoder
05	Incremental rotary encoder with electronic counting
06	Incremental linear encoder
07	Incremental linear encoder with electronic counting
08	Absolute linear encoder
09	Absolute linear encoder with cyclic coding
10	Multi-Sensor encoder interface
11	Multi-Turn absolute rotary encoder with electronic turn count
12	Virtual Axis Sensor
13... 65535	Reserved by DeviceNet

5-23.4.7 Direction Counting Toggle – Attribute 12

For linear devices, the *Position Value* attribute increases when the value of the *Direction Counting Toggle* attribute is FORWARD/CW (0). If the value of the *Direction Counting Toggle* attribute is REVERSE/CCW (1), the *Position Value* attribute decreases. The *Direction Counting Toggle* defines the increasing *Position Value* 1) for rotary devices as clockwise shaft rotation or counter clockwise as viewed facing the mounting face (CW = 0, CCW = 1), 2) for linear devices as Forward, moving away from the electrical connection, or Reverse, moving toward the electrical connection, as viewed from the mounting face. Changing this value shall change the sign of velocity and position relative to physical movement.

For rotary encoders the code sequence defines whether increasing or decreasing position values are output when the encoder shaft rotates clockwise (CW) or counterclockwise (CCW) as seen on the shaft. Example: By turning the shaft clockwise the *Position Value* attribute will increase when *Direction Counting Toggle* is defined as clockwise (0=CW).

5-23.4.8 Commissioning Diagnostic Control – Attribute 13

When the *Commissioning Diagnostic Control* attribute is set to ON (1) it is possible to check the encoder components responsible for position detection at encoder stand still. This enables an extensive check of the correctness of the position values.

If errors are detected, they will be indicated by the respective bits in the *Alarm* attribute. If this attribute is set to OFF (0), no diagnostics will be executed.

5-23.4.9 Scaling Function Control – Attribute 14

When the *Scaling Function Control* attribute is set to ON (1), the *Position Value* attribute is converted from the physical resolution of the device to position units.

If this attribute is implemented and turned OFF, all functions within position sensor shall continue to use the scaled value, except the *Position Value* (attribute 10) reported shall be the raw, unscaled value. This attribute is provided solely for calibration and troubleshooting purposes and does not affect scaling when *Position Format* (attribute 15) and *Measuring Units per Span* (attribute 16) are implemented.

The *Measuring Units per Revolution* and *Total Measuring Range in Measuring Units* attributes are the scaling parameters.

For rotary devices:

If *Scaling Function Control* = = OFF

Then Position Value = physical resolution of device in counts

If S*caling Function Control* = = ON

The Position Value = physical resolution of device in counts * (*Measuring Units per Span* (attribute 16) / *Physical Resolution Span* (attribute 42))

If *Measuring Units per Span* and *Total Measuring Range in Measuring Units* are not supported, the scaling of the *Position Value* is not provided and the *Position Value* is always equal to physical resolution of the device in counts.

If *Scaling Function Control* is not supported, the *Position Value* shall always be scaled based upon the values within *Position Format* and *Measuring Units per Span* attributes. When the *Scaling Function Control* attribute is supported and is enabled (ON=1), P*osition Value* is calculated according to the formula above. When disabled, physical resolution shall be contained in *Position Value*.

5-23.4.10 Position Format – Attribute 15

This attribute identifies the engineering units for the *Position Value* attribute (attribute 3 or 10). *Position Format* is a component of all other attributes containing a distance data type, like *Velocity Value* (attribute 24) and *Acceleration Value* (attribute 29). Engineering units like counts, mm or inches are allowed.

The *Position Format* (attribute 3 or 10) identifies the engineering units for one increment of the *Position Value*. The *Position Measuring Increment* (attribute 18) indicates the smallest granularity that the *Position Value* (attribute 3 or 10) shall change.

5-23.4.11 Measuring Units per Span – Attribute 16

The *Measuring Units per Span* sets the number of distinguishable (desired) steps per unit of travel. Rotary units would contain the counts per one complete span.

5-23.4.12 Total Measuring Range in Measuring Units – Attribute 17

The parameter *Total Measuring Range in Measuring Units* sets the number of distinguishable steps over the total measuring range. This value must be less than maximum physical resolution of the device. Maximum physical resolution should be listed on the type plate.

This parameter is used for rotary and linear devices..

5-23.4.13 Position measuring increment – Attribute 18

This attribute may be supported when *Position Format* (attribute 15) can be set to a value other than count (0x1001). The *Position Measuring Step* attribute defines the measuring step settings for the position for linear encoders. Basic position measuring step in 0.001 µm or 0.1nanoinch is affected by *Position Format* (attribute 15).

5-23.4.14 Preset Value – Attribute 19

This attribute supports adapting a desired position value to an actual position value.

At the instant a "Set Attribute" to attribute #19 is performed, the following occurs:

Attribute #19 (*Preset Value*) is set to the service data of the request.

Offset Value (Attribute #51) is set to the value resulting from [*Preset Value*] - [*Position Value*]

During operation, the formula is immaterial and the behavior of the device is:

Position Value = (internal position value) + *Offset Value*

The value contained in the *Preset Value* attribute is meaningless (with respect to the indicated position) after the Set Attribute has taken effect. The *Offset Value* remains a constant and the now reported *Position Value* is the adjusted position value using the offset applied to some (internal) raw position value.

The non-settable attribute (from explicit messaging) is actually set (e.g. the *Offset Value* attribute must change) by an internal mechanism.

Preset Value (attribute 19) = *Position Value* (attribute 10) + *Offset Value* (attribute 51).

5-23.4.15 COS Delta – Attribute 20

A COS I/O message will be generated when the *Positon Value* (attribute 3 or 10) changes by this value. Setting this value to 0 disables COS delta limit for *Position Value* (attribute 3 or 10) changes and all position changes shall generate a COS message.

5-23.4.16 Position State Register, Position limits – Attributes 21 to 23

The *Position Low Limit* and *Position High Limit* attributes configure the actual work area. The *Position State Register* contains the actual area status of the encoder position. If the position is out of range, a bit will be set in the *Position State Register* attribute. If the position is lower than the position value set in *Position Low Limit*, then bit 2 flags the underflow. If the position is higher than the position value set in *Position High Limit*, then bit 1 flags the overflow. The *Position Limits* define a configurable work area within the measuring range. This function allows a replacement of external proximity switches.

Table 5-23.9 Position State Register Structure

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved	Reserved	Reserved	Reserved	Reserved	Range underflow	Range overflow	Out of range

5-23.4.17 Velocity Format– Attribute 25

This *Velocity Format* attribute identifies the engineering units for the *Velocity Value* attribute (attribute 24). Default is counts (steps) per second. Any reasonable format from Appendix D-2.30 may be used depending upon application requirements. *Velocity Format* is a component of all other attributes containing velocity for calculation like acceleration. If this attribute is changed, both *Minimum Velocity* and *Maximum Velocity* Setpoints shall be reset to their default values. This attribute is required when *Velocity Value* is implemented. Otherwise, this attribute is not implemented.

5-23.4.18 Velocity Resolution – Attribute 26

The parameter *Velocity Resolution* defines the resolution of the *Velocity Value* attribute. Basic velocity resolution is defined in steps of 0.01 mm /s or 0.001 inch/s, affected by the chosen *Position Format* (attribute 15). This attribute is required when *Velocity Value* is implemented. Otherwise, this attribute is not implemented.

5-23.4.19 Minimum Velocity / Maximum Velocity - Attribute 27 thru 28

The actual velocity speed limit values with minimum and maximum can be configured in attributes 27 and 28. Corresponding flags in *Status Warnings* (attribute 68) are affected. These attributes are optional when *Velocity Value* is implemented.

5-23.4.20 Acceleration Value - Attribute 29

Acceleration is defined as the change of velocity (speed) per time unit. The time unit used should be seconds. This means the *Acceleration Value* is given in "*Velocity Format*" per second. The current *Acceleration Value* is derived from the calculated *Velocity Value*. The value is signed with the following meaning.

Table 5-23.10 Acceleration Value Attribute

Value (sign)	Explanation
0	Velocity is constant
+	Velocity is increasing
-	Velocity is decreasing

5-23.4.21 Acceleration Format – Attribute 30

This attribute identifies the engineering units for the *Acceleration Value* (attribute 29). Default is meters/second. Any reasonable format from Appendix D-2.8 may be used depending upon application requirements. If this attribute is changed, both *Minimum Acceleration Setpoint* and *Maximum Acceleration Setpoint* shall be reset to their default values. This attribute is required when *Acceleration Value* is implemented. Otherwise, this attribute is not implemented.

5-23.4.22 Acceleration Resolution – Attribute 31

The parameter *Acceleration Resolution* defines the resolution of the *Acceleration Value* attribute. Basic *Acceleration Resolution* is defined in steps of 1 mm/s^2 or 0,1 $inch/s^2$, affected by the chosen *Position Format* [attribute15]. This attribute is required when *Acceleration Value* is implemented. Otherwise, this attribute is not implemented.

5-23.4.23 Minimum Acceleration / Maximum Acceleration - Attribute 32 thru 33

The actual acceleration limit values with minimum and maximum can be configured in the attributes 32 and 33. Corresponding flags in status *Warnings* (attribute 47) are affected. These attributes are optional when *Acceleration Value* is implemented. Otherwise, these attributes are not implemented.

5-23.4.24 Number of CAM Channels – Attribute 34

This attribute defines the number of cam channels that are supported by an encoder device. Each cam has parameters for the minimum switch point, the maximum switch point and setting a hysteresis to the switch points. If this attribute is implemented then attributes 35-40 shall be implemented. If this attribute is NOT implemented then attributes 35-40 shall NOT be implemented.

Figure 5-23.11 Possible Usage of Cam's and Switch Points

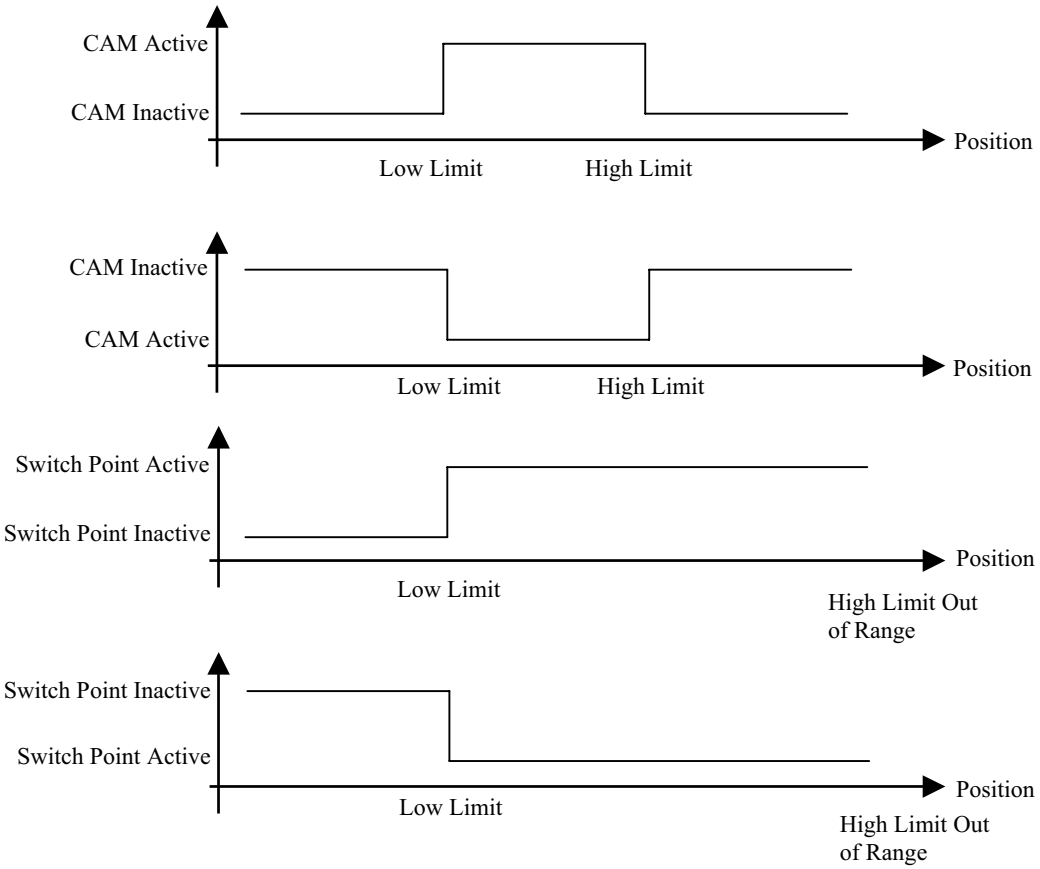
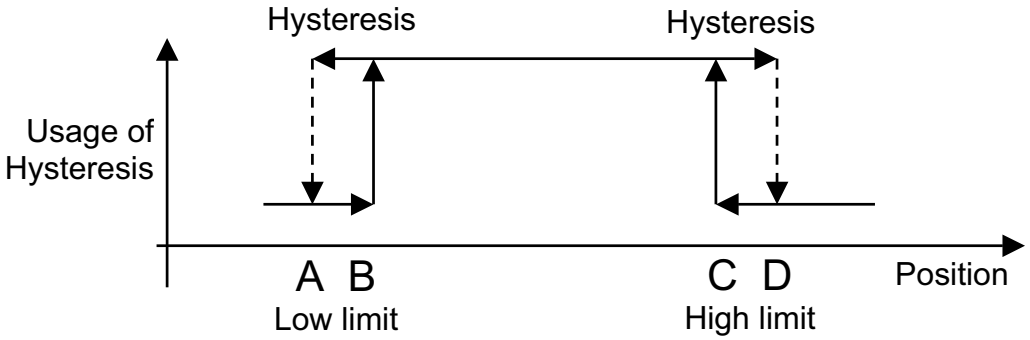
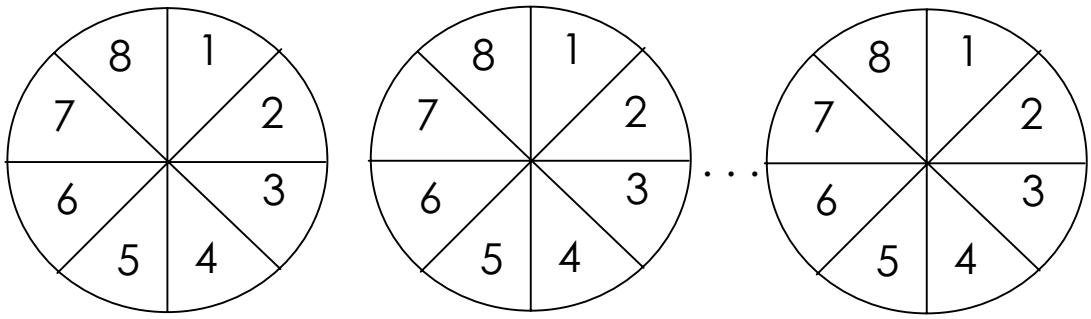


Figure 5-23.12 Possible Usage of Hysteresis



A Low Limit trip occurs at the lower "A" value (dashed left down arrow) and is rest at "B" threshold (the higher solid left up arrow). A High Limit trip occurs at the higher "D" value (dashed right down arrow) and is reset at the lower "C" threshold (solid right up arrow).

Figure 5-23.13 Principle of CAM Channels



Where: N = Number of CAM channels

5-23.4.25 CAM Channel State Register – Attribute 35

This attribute defines the status bit of the cam. The status bit set to 1 defines "cam active". The status bit set to 0 defines "cam inactive". If the *CAM Polarity Register* attribute of a cam is set to one, the actual cam state will be inverted. The *CAM Channel State Register* array size is determined by the value of the *Number of CAM Channels* attribute 34.

Table 5-23.14 Cam Channel State register for CAM Channel N

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
CAM_ 8	CAM_ 7	CAM_ 6	CAM_ 5	CAM_ 4	CAM_ 3	CAM_ 2	CAM_ 1
State	State	State	State	State	State	State	State
N = Number of CAM channel, with respect to Attribute 34							

5-23.4.26 CAM Channel Polarity Register – Attribute 36

This attribute contains the actual polarity settings for *Cam Channel State Register*. If the *CAM Polarity Register* bit is set to 1, the cam state of an active cam will signal by setting the related cam state bit to zero. In the other case, the cam state of the related cam will not be inverted.

Table 5-23.15 CAM Polarity Register of CAM Channel N

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
CAM_8	CAM_7	CAM_6	CAM_5	CAM_4	CAM_3	CAM_2	CAM_1
Polarity	Polarity	Polarity	Polarity	Polarity	Polarity	Polarity	Polarity
N = Number of CAM channel, with respect to Attribute 34							

5-23.4.27 CAM Channel Enable Register – Attribute 37

The *Cam Channel Enable Register* contains the calculation state for the respective cams. If the *Cam Channel Enable Register* bit is set to 1, the cam state will be calculated by the device. In the other case the cam state of the related cam will be set permanently to 0.

Table 5-23.16 CAM Enable Register of CAM Channel N

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
CAM_8	CAM_7	CAM_6	CAM_5	CAM_4	CAM_3	CAM_2	CAM_1
Enable	Enable	Enable	Enable	Enable	Enable	Enable	Enable
N=Number of CAM channel, with respect to Attribute 34							

5-23.4.28 CAM Low Limit – Attribute 38

Each cam channel contains the switch point for the lower limit setting for a maximum of 8 cams for one cam channel. The *CAM Low Limit* array size is determined by the value of the *Number of CAM Channels* attribute 34. The default value for this attribute is zero.

5-23.4.29 CAM High Limit – Attribute 39

Each cam channel contains the switch point for the higher limit setting for a maximum of 8 cams for one cam channel. The *CAM High Limit* array size is determined by the value of the *Number of CAM Channels* attribute 34. The default value for this attribute is zero.

5-23.4.30 CAM Hysteresis – Attribute 40

The *CAM Hysteresis* value is added to the *CAM High Limit* and subtracted from the *CAM Low Limit* when calculating the CAM state. The *CAM Hysteresis* array size is determined by the value of the *Number of CAM Channels* attribute 34.

5-23.4.31 Operating Status – Attribute 41

This attribute contains the operating status of the encoder.

Table 5-23.17 Operating Status Attribute Bit Definitions

Bit	Description	FALSE (0)	TRUE (1)
0	Direction	Increasing	Decreasing
1	Scaling	Off	On
2..4	Reserved by DeviceNet		
5..7	Vendor specific		

5-23.4.32 Physical Resolution – Attribute 42

This is the physical resolution of the position sensor. For rotary devices, the number of steps per span can be read out. For linear devices, the units are steps per linear unit (nanometer or 0.1 nanoinch) the measuring step is given for linear encoder.

5-23.4.33 Number of Spans – Attribute 43

For a multi-Turn device the *Number of Spans* and the *Physical Resolution* (attribute 42) gives the physical measuring range to the formula below.

Physical Measuring range = *Physical Resolution* * *Number of Spans*

5-23.4.34 Alarms – Attribute 44

An alarm is set if a malfunction bit is set to true (high). The alarm remains active until the alarm is cleared and the device is able to provide an accurate position value.

Table 5-23.18 Alarms Attribute Bit Definitions

Bit	Description	FALSE (0)	TRUE (1)
0	Position error	NO	YES
1	Diagnostic error	NO	YES
2…11	Reserved by DeviceNet		
12…15	Vendor specific		

5-23.4.35 Supported Alarms – Attribute 45

This attribute contains information on supported alarms by the position sensor device. This attribute is required when the *Alarms* attribute is implemented.

Table 5-23.19 Supported Alarms Attribute Bit Definitions

Bit	Description	FALSE (0)	TRUE (1)
0	Position error	Not supported	Supported
1	Diagnostic error	Not supported	Supported
2…11	Reserved by DeviceNet		
12…15	Vendor specific		

5-23.4.36 Alarm Flag – Attribute 46

Indicates that an alarm error has occurred. This attribute is the logical OR of all the alarm bits in the *Alarms* attribute (attribute 44). This attribute is required when the *Alarms* attribute is implemented.

5-23.4.37 Warnings – Attribute 47

The *Warnings* attribute indicates that tolerance for certain internal parameters of the device have been exceeded. In contrast to alarms, warnings do not imply incorrect position values. All warnings are cleared if the tolerances are again within normal parameters. For the operating time limit warning (bit 3) the warning is only set again after a power-on sequence. The *Warning Flag* attribute indicates if any of the defined warnings are active.

Table 5-23.20 Warnings Attribute Bit Definitions

Bit	Description	FALSE (0)	TRUE (1)
0	Frequency Exceeded	NO	YES
1	Light Control reserve	Not reached	Error
2	CPU Watchdog	OK	Reset generated
3	Operating Time Limit Warning	NO	YES
4	Battery charge	OK	Too low
5	Reference Point	Reached	Not reached
6	Minimum Velocity Flag	OK	Fall below
7	Maximum Velocity Flag	OK	Exceeded
8	Minimum Acceleration Flag	OK	Fall below
9	Maximum Acceleration Flag	OK	Exceeded
10	Position Limits Exceeded	OK	Exceeded
11-12	Reserved by DeviceNet	Always 0	
13-15	Vendor specific		

5-23.4.38 Supported Warnings – Attribute 48

This attribute contains information on supported warnings by the position sensor device. This attribute is required when the *Warnings* attribute is implemented.

Table 5-23.21 Supported Warnings Attribute Bit Definitions

Bit	Description	FALSE (0)	TRUE (1)
0	Frequency Exceeded	Not supported	Supported
1	Light Control reserve	Not supported	Supported
2	CPU Watchdog	Not supported	Supported
3	Operating Time Limit Warning	Not supported	Supported
4	Battery charge	Not supported	Supported
5	Reference Point	Not supported	Supported
6	Minimum Velocity Flag	Not supported	Supported
7	Maximum Velocity Flag	Not supported	Supported
8	Minimum Acceleration Flag	Not supported	Supported
9	Maximum Acceleration Flag	Not supported	Supported
10	Position Limits Exceeded	OK	Exceeded
11-12	Reserved by DeviceNet	Always 0	
13-15	Vendor specific		

5-23.4.39 Warning flag – Attribute 49

Indicates that warning error has occurred. This attribute is the logical OR of all the warnings bits in the *Warnings* attribute (attribute 47). This attribute is required when the *Warnings* attribute is implemented.

5-23.4.40 Operating Time – Attribute 50

This attribute is incremented as long as the encoder is powered. The *Operating Time* value is presented in tenths (0.1) of an hour.

5-23.4.41 Offset Value – Attribute 51

This attribute is required when the *Preset Value* (attribute19) is implemented.

The *Offset Value* attribute is calculated by the preset function and shifts the *Position Value* attribute with the calculated value. The *Offset Value* is stored automatically by the device and can be read from the encoder for diagnostic purposes.

Offset Value (attribute 49) = *Preset Value* (attribute 19) - *Position Value* (attribute10).

5-23.5 Common Services

The Position Sensor Object provides the following Common Services:

Table 5-23.22 Position Sensor Object Common Service

Service Code	Need In Implementation		Service Name	Description of Service
	Class	Instance		
0x05	Optional	NA	Reset	Resets all parameter values to the factory default
0x0D	Optional	NA	Apply_Attributes	Cause the configuration to become active
0x0E	Conditional *	Required	Get_Attribute_Single	Returns the contents of the specified attribute
0x10	N/A	Optional	Set_Attribute_Single	Modifies an attribute value
0x15	Optional	NA	Restore	Restores all parameter values from non-volatile storage
0x16	Optional	NA	Save	Saves all parameters to non-volatile storage
0x18	N/A	Conditional **	Get_Member	Returns an element of an array for specified attribute. Specifically intended for usage on “CAM” attributes.
0x19	N/A	Conditional **	Set_Member	Modifies an element of an array for specified attribute. Specifically intended for usage on “CAM” attributes.

* The Get_Attribute_Single service is *required* at the class level if any class attributes are implemented

** The Get_Member and Set_Member services are required when any of the array attributes are implemented.

See Appendix A for definition of these services

If several parameters will be modified resulting in side effects the Apply_Attributes service shall be implemented to cause the configuration to become active after all parameters have been set. The Apply_Attributes service shall validate parameter settings. If any parameters are in conflict, the error response Invalid value (0x09) shall be returned with the extended error code indicating the conflicting attribute Id.

If Save or Restore service is implemented, all implemented attributes of the Position Sensor Object must be restored or saved to non-volatile storage.

The reset service has the following parameter:

Table 5-23.23 Reset Service

Name	Type	Description of Request Parameters	Semantics of Values
Type	USINT	Type of Reset	See Table below

The parameter Type for the Reset service has the following bit specifications:

Table 5-23.24 Reset Service Parameter Values

Value	Type of Reset
0	Emulate as closely as possible cycling power. This value is the default if this parameter is omitted.
1	Return as closely as possible to the out-of-box configuration, then emulate cycling power as closely as possible.

5-23.6 Object–specific Services

The Position Sensor Object provides no Object–specific services.

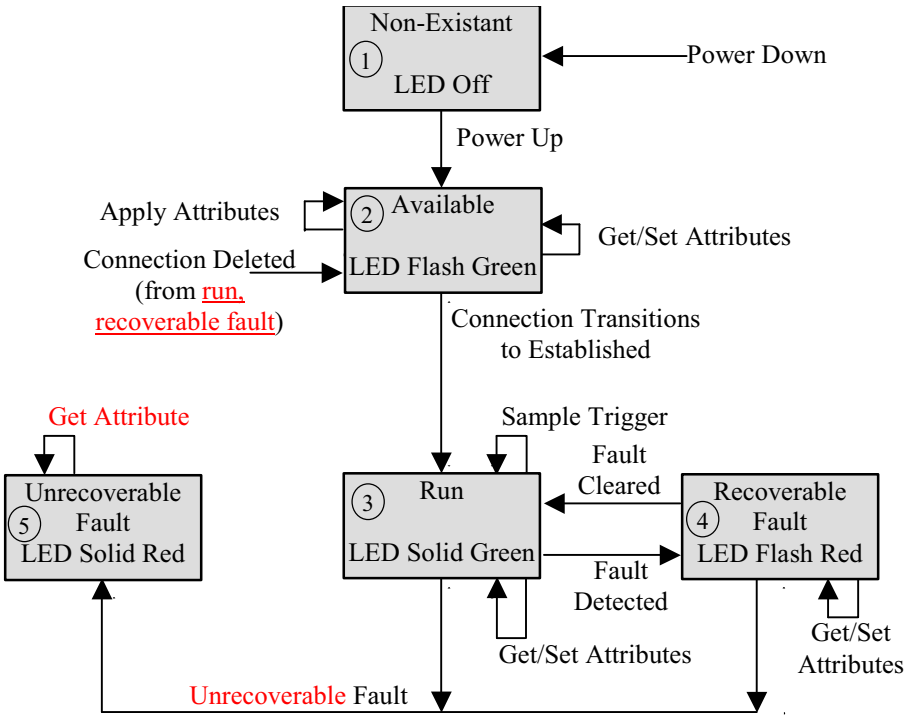
5-23.7 Behavior

The State Transition Diagram (Figure 5-23.27) provides a graphical description of the events and corresponding state transitions. A subset of the states and events may be supported in an application, but the behavior must be consistent.

The State Event Matrix (See Table 5-23.28) lists all pertinent events and the corresponding action to be taken while in each state.

Important: Events can occur simultaneously, but the *Fault* events have priority if they occur simultaneously with other events.

Figure 5-23.25 State Transition Diagram for Position Sensor Object



LED = I/O Status LED

Important: Events can occur simultaneously, but the *Fault* events have priority if they occur simultaneously with other events.
The following SEM contains these states:

- ***Non–Existent:*** a module without power.
- ***Available:*** waiting for a connection, power–up discrete input point defaults are set.
- ***Run:*** Position Sensor sensing data from its input and transmitting the data.
- ***Recoverable Fault:*** a recoverable fault has occurred.
- ***Unrecoverable Fault:*** an unrecoverable fault has occurred.

The SEM also contains these events:

Table 5-23.26 Position Sensor Object Event Definitions

This event	Is
Sample Trigger	a change of state, cyclic timer trigger, application trigger
Connection Deleted	I/O connection deleted.
Apply_Attributes	the Apply service of the I/O connection object the Position Sensor Object is connected to. Note: the application is responsible for validating the connection object's attributes.
Fault Cleared	the application clearing a detected fault
Connection Transitions to Established	I/O connection transitions to Established.
Connection Transitions to Timed Out state	I/O connection transitions to Timed-Out

The figure below is a **conceptual** illustration of the state machine for a typical input object (producing application). The events listed above are represented by the dotted line labeled "state change."

Figure 5-23.27 Conceptual Position Sensor Object Operation

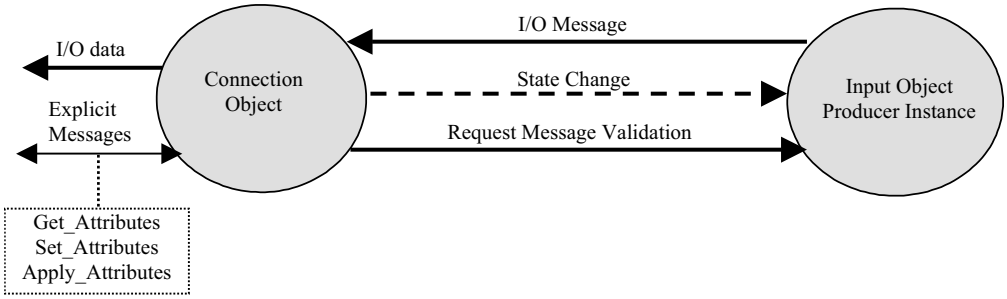


Table 5-23.28 State Event Matrix for the Position Sensor Object

Event	State				
	Non-Existent	**Available**	**Run**	**Recoverable Fault**	**Unrecoverable Fault**
Sample Trigger	Not Applicable	Ignore event	Sample data, Send data	Ignore event	Ignore event
Apply Attributes	Not Applicable	Verify attributes, return result	Return error (Object State Conflict)	Return error (Object State Conflict)	Ignore event
Connection Deleted	Not Applicable	Ignore Event	Transition to Available	Transition to Available	Ignore event
Connection Transitions to Established	Not Applicable	Transition to Run	Ignore event	Ignore event	Ignore event
Connection Transitions to Timed Out state	Not Applicable	Ignore event	Transition to Recoverable Fault	Ignore event	Ignore event
Fault Cleared	Not Applicable	Not Applicable	Not Applicable	Transition to Run	Ignore event
Get_Attribute	Return Error (Object Does Not Exist)	Return value	Return value	Return value	Return Value
Set_Attribute	Return Error (Object Does Not Exist)	Accept value	Accept value	Accept value	Ignore event
I/O Status LED	Off	Off	Solid Green	Flash Red	Solid Red
Reset	Not Applicable	Perform service	Perform service	Attempt to Recover	Ignore Event
Restore	Not Applicable	Restore from storage	Restore from storage	Ignore Event	Ignore Event
Save	Not Applicable	Stores parameter to non-volatile memory	Stores parameter to non-volatile memory	Ignore Event	Ignore Event