

The Absolute Position Calibration and Accuracy Calibration

Draft

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Document version

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Which encoder needs/supports this function?

The Ressource 0x114 is supported by the following encoders:

- [ENS35 / ENM35 without ball bearing Firmware v24.3 and later](#)

Links

Videos:

[Absolute position calibration with the PGT-13-S web GUI](#)

[Absolute position calibration using the raw data](#)

[The mounting of a ENS35 / ENM35](#)

FAQs:

[The mounting of a ENS35 / ENM35](#)

[The calibration of the ENS35 / ENM35](#)

Absolute position calibration

Why

The ENS35 / ENM35 is available as a bearing less optical encoder. So far, at our previous encoders (with ball bearings), we have done the synchronisation mechanically in our production.

Due to the fact, that the mechanical alignment at the ENS35 / ENM35 is finally done in the motor, the synchronisation has to be done after the mounting in the motor. At the ENS35 / ENM35, this is a electronic procedure. This step is essential for a well working encoder.

In the absolute position calibration, the SIN/COS track and the absolute position track are synchronized.



The RID 0x114 needs the access level "4" (default access code: "4444").

Please ensure that the encoder is logged in in the access level 4, when doing the absolute position calibration and accuracy calibration.

How to perform the process

1 Prepare the "absolute position calibration"

Execute the RID 0x114, offset 2048, data length 0, write, no data.

It doesn't care, if the motor is turning in this step. Please keep in mind, the encoder will not send an absolute position for approx 5ms.

This step is mandatory for the "absolute position calibration".

RID	Access	Offset (y/n)	Offset	Data length	R/W	Data
0x114	indirect	y	2048 (0x800)	0	W	--

2 Start the "absolute position calibration"

Turn the motor at 300 .. 1050 rpm (recommend 1000 rpm).



It should be ensured, that the motor is constant turning. The rotation speed doesn't has to be very steady.

Execute the RID 0x114, no offset, (offset 0), data length 0, write, no data.

This step will be acknowledged by the FREL Bit "1", when the process is finished (approx. after 3 sec).

RID	Access	Offset (y/n)	Offset	Data length	R/W	Data
0x114	indirect	n	(0)	0	W	--

3 Read out the "absolute position calibration" data "before calibration"

This step is only working, if the step "absolute position calibration" was executed before. If step the "absolute position calibration" was not executed, all responded values will be "00".

It is possible to read out the raw adjustment data by executing the RID 0x114, offset 0 .. 3, data length 8, read (4 long messages in total)

RID	Access	Offset (y/n)	Offset	Data length	R/W	Data
0x114	indirect	y	0 .. 3	8	R	--

The response is as followed:

	Byte 0 / Byte 1	Byte 2 / Byte 3	Byte 4 / Byte 5	Byte 6 / Byte 7
Offset 0	min. odd value	max. odd value	min. even value	max. even value
Offset 1	middle global value	absolute phase delta value	increments to absolute even value	reserved
Offset 2	min. rise value	max. rise value	min. fall value	max. fall value
Offset 3	middle rise value	middle fall value	duty-cycle value	threshold value (8 bit) / reserved

(all values are 16 bit unsigned)

Make a "Reset" of the encoder (RID100, offset, offset 0, data length 0, write, no data).

The evaluation is explained in the step "The evaluation of the received data".

4 Make a "Reset" of the encoder

The Reset is important, that the data is stored into the micro controller of the ENS35 / ENM35

RID	Access	Offset (y/n)	Offset	Data length	R/W	Data
0x100	indirect	n	(0)	0	W	--

5 Prepare to tests the result of the "absolute position calibration"

Execute the RID 0x114, offset 2304, data length 0, write, no data.

It doesn't care, if the motor is turning in this step. Please keep in mind, the encoder will not send an absolute position for approx 5ms.

This step is mandatory for the "absolute position calibration"

RID	Access	Offset (y/n)	Offset	Data length	R/W	Data
0x114	indirect	y	2304 (0x900)	0	W	--

6 Tests the result of the "absolute position calibration"

Turn the motor at 300 .. 1050 rpm (recommend 1000 rpm).



It should be ensured, that the motor is constant turning. The rotation speed doesn't has to be very steady.

It is possible to check the quality of the absolute position calibration by executing the RID 0x114, offset 256, data length 0, write, no data.

This step will be acknowledged by the FREL Bit "1", when the process is finished (approx. after 3 sec).

RID	Access	Offset (y/n)	Offset	Data length	R/W	Data
0x114	indirect	y	256 (0x100)	0	W	--

7 Read out the "absolute position calibration" data "after calibration"

This step is only working, if the step "result of the absolute position calibration" was executed before. If the step "result of the absolute position calibration" was not executed, all responded values will be "00".

It is possible to read out the corrected adjustment data by executing the RID 0x114, offset 256 .. 259, data length 8, read (4 long messages in total).

RID	Access	Offset (y/n)	Offset	Data length	R/W	Data
0x114	indirect	y	256 (0x100) .. 259 (0x103)	8	R	--

The response is as followed:

	Byte 0 / Byte 1	Byte 2 / Byte 3	Byte 4 / Byte 5	Byte 6 / Byte 7
Offset 256	min. odd value	max. odd value	min. even value	max. even value
Offset 257	middle global value	absolute phase delta value	increments to absolute even value	reserved
Offset 258	min. rise value	max. rise value	min. fall value	max. fall value
Offset 259	middle rise value	middle fall value	duty-cycle value	threshold value (8 bit) / reserved

Make a reset of the encoder (RID100, offset, offset 0, data length 0, write, no data)

The evaluation should show an improvement of the values (The evaluation is explained in the step "The evaluation of the received data")

8 Make a "Reset" of the encoder

The Reset is important, that the data is stored into the micro controller of the ENS35 / ENM35

RID	Access	Offset (y/n)	Offset	Data length	R/W	Data
0x100	indirect	n	(0)	0	W	--

9 The evaluation of the received data

1a. Calculate the middle odd value:

if $MaxOddValue < MinOddValue$

$$then \ MiddleOddValue = \frac{MaxOddValue + 2^{16} + MinOddValue}{2} \text{ Modulo } 2^{16}$$

$$else \ MiddleOddValue = \frac{MaxOddValue + MinOddValue}{2}$$

1b. Calculate the middle even value:

if $MaxEvenValue < MinEvenValue$

$$then \ MiddleEvenValue = \frac{MaxEvenValue + 2^{16} + MinEvenValue}{2} \text{ Modulo } 2^{16}$$

$$else \ MiddleEvenValue = \frac{MaxEvenValue + MinEvenValue}{2}$$

As a result, you get 2 values

- middle odd value
- middle even value

One of both values must be close to "0", the other one close to $32'768 (2^{15})$

The tolerance is " ± 1000 "

2. Calculate the delta of the middle values:

$$\Delta(\text{MiddleOddValue: MiddleEvenValue}) \approx 2^{15}$$

The Δ of the 2 values must be close to $32'768 (2^{15})$

The tolerance is " ± 1000 "

3. Evaluate the middle global value:

Middle global value \approx *MiddleOddValue*

or

Middle global value \approx *MiddleEvenValue*

The "middle global value" is a "signed" value

One of the 2 values should be close to "0"

The tolerance is " ± 1000 "

4. Evaluate middle rise value and middle fall value:

MiddleRiseValue \approx *MiddleFallValue*

The "middle rise value" and the "middle fall value" are "signed" values

The difference of the 2 values must be less than " ± 500 "

5. Evaluate duty-cycle value:

$DutyCycleValue \approx 0.5$

To get the right duty cycle value, the decimal point must be shifted 3 digits to the left.

The duty cycle must be close to 0.500

The tolerance is " ± 0.03 "

10 Possible errors and problems

Long Message error: 0x42 0x12 (internal processing error)

- Rotation speed 300 .. 1050 rpm we suggest 500 rpm

PGT-13-S GUI

[Video Link](#)

Done with the PGT-13-S, explained by the commands

[Video Link](#)

The Accuracy Calibration

Why

To achieve a better non linearity performance in a motor.

Before the accuracy calibration is started, it is important to do the "absolute position calibration" (the previous described progress).



The RID 0x114 needs the access level "4" (default access code: "4444"). Please ensure that the encoder is logged in in the access level 4, when doing the absolute position calibration and accuracy calibration.

How to perform the process

1 Prepare the "accuracy calibration"

Execute the RID 0x114, offset 2560, data length 0, write, no data.


It doesn't care, if the motor is turning in this step. Please keep in mind, the encoder will not send an absolute position for approx 5ms.

This step is mandatory for the "accuracy calibration"

RID	Access	Offset (y/n)	Offset	Data length	R/W	Data
0x114	indirect	y	2560 (0xA00)	0	W	--

2 Start the "accuracy calibration"

Turn the motor at 300 .. 1050 rpm (recommend 1000 rpm).

 The rotation speed has to be very steady. Because the quality of the steady rotation speed has an influence to the accuracy calibration.

Execute the RID 0x114, offset 512, data length 0, write, no data.

This step will be acknowledged by the FREL Bit "1", when the process is finished (approx. after 3 sec).

RID	Access	Offset (y/n)	Offset	Data length	R/W	Data
0x114	indirect	y	512 (0x200)	0	W	--

3 Read out the "accuracy calibration" data "before calibration"

This step is only working, if the step "accuracy calibration" was executed before. If the step "accuracy calibration" was not executed, all responded values will be "00".

It is possible to read out the raw linearisation data by executing the RID 0x114, offset 512 .. 544, data length 8, read (33 long messages in total).

The received data shows the linearisation before the "accuracy calibration".

RID	Access	Offset (y/n)	Offset	Data length	R/W	Data
0x114	indirect	y	512 (0x200) .. 544 (0x220)	8	R	--

The response is as followed:

	Byte 0 / Byte 1	Byte 2 / Byte 3	Byte 4 / Byte 5	Byte 6 / Byte 7
Offset 512	peak-peak value (32 bit)		reserved	reserved
Offset 513	Index 000	Index 001	Index 002	Index 003
Offset 514	Index 004	Index 005	Index 006	Index 007
Offset 515 .. Offset 542	Index ...	Index ...	Index ...	Index ...
Offset 543	Index 120	Index 121	Index 122	Index 123
Offset 544	Index 124	Index 125	Index 126	Index 127

 The values 513 .. 544 are 16 bit signed.

The resolution of the received values is in the raw resolution of the ENS35 / ENM35, which is 2^{26} . 1 digit = 0,019 angular sec.

Make a Reset of the encoder (RID100, offset, offset 0, data length 0, write, no data)

The evaluation is explained in the step "The evaluation of the received data".

4 Make a "Reset" of the encoder

The Reset is important, that the data is stored into the micro controller of the ENS35 / ENM35

RID	Access	Offset (y/n)	Offset	Data length	R/W	Data
0x100	indirect	n	(0)	0	W	--

5 Prepare to tests the result of the "accuracy calibration"

Execute the RID 0x114, offset 3072, data length 0, write, no data.

It doesn't care, if the motor is turning in this step. Please keep in mind, the encoder will not send an absolute position for approx 5ms.

This step is mandatory for the "test of the accuracy calibration"

RID	Access	Offset (y/n)	Offset	Data length	R/W	Data
0x114	indirect	y	3072 (0xC00)	0	W	--

6 Tests the result of the "accuracy calibration"

Turn the motor at 300 .. 1050 rpm (recommend 1000 rpm).



The rotation speed has to be very steady. Because the quality of the steady rotation speed has an influence to the accuracy calibration.

It is possible to check the quality of the accuracy calibration by execution the RID 0x114, offset 1024, data length 0, write, no data.

This step will be acknowledged by the FREL Bit "1", when the process is finished (approx. after 3 sec).

RID	Access	Offset (y/n)	Offset	Data length	R/W	Data
0x114	indirect	y	1024 (0x400)	0	W	--

7 Read out the "accuracy calibration" data "after calibration"

This step is only working, if the step "result of the accuracy calibration" was executed before. If the step "result of the accuracy calibration" was not executed, all responded values will be "00".

It is possible to read out the corrected linearisation data by executing the RID 0x114, offset 1024 .. 1056, data length 8, read (33 long messages in total)

The received data shows the linearisation after the "accuracy calibration".

RID	Access	Offset (y/n)	Offset	Data length	R/W	Data
0x114	indirect	y	1024 (0x400) .. 1056 (0x420)	8	R	--

The response is as followed:

	Byte 0 / Byte 1	Byte 2 / Byte 3	Byte 4 / Byte 5	Byte 6 / Byte 7
Offset 1024	peak-peak value (32 bit)		reserved	reserved
Offset 1025	Index 000	Index 001	Index 002	Index 003
Offset 1026	Index 004	Index 005	Index 006	Index 007
Offset 1027 .. Offset 1054	Index ...	Index ...	Index ...	Index ...
Offset 1055	Index 120	Index 121	Index 122	Index 123
Offset 1056	Index 124	Index 125	Index 126	Index 127



The values 513 .. 544 are 16 bit signed.

The resolution of the received values is in the raw resolution of the ENS35 / ENM35, which is 2^{26} . 1 digit = 0,019 angular sec.

Make a Reset of the encoder (RID100, offset, offset 0, data length 0, write, no data).

The evaluation should show an improvement of the values (The evaluation is explained in the step "The evaluation of the received data")

8 Make a "Reset" of the encoder

The Reset is important, that the data is stored into the micro controller of the ENS35 / ENM35

RID	Access	Offset (y/n)	Offset	Data length	R/W	Data
0x100	indirect	n	(0)	0	W	--

9 The evaluation of the received data

The evaluation is done as followed:

1. in the 1st offset (offset 1024), we find the 32 bit peak to peak value
2. in the other 32 offsets (offset 1025 .. 1056), we find the linearisation correction values (4 values each offset, 128 values in total, for 360°)
3. With the values, it is possible to display the linearisation of the encoder (before and after the "accuracy calibration")



The values 513 .. 544 are 16 bit signed.

The resolution of the received values is in the raw resolution of the ENS35 / ENM35, which is 2^{26} . 1 digit = 0,019 angular sec.

10 Possible errors and problems

Long Message error: 0x42 0x12 (internal processing error)

- Rotation speed 300 .. 1050 rpm we suggest 500 rpm
- INL peak to peak value exceeds the maximum value for INL calibration during the calibration or analysis

PGT-13-S GUI

Video Link will follow

Done with the PGT-13-S, explained by the commands

The calibration table

The calibration table is used to correct the accuracy error. The correction table can be enabled or disabled. It is also possible to edit the 128 correction points manually.

Correction table Status

It is possible, to enable or disable the "correction table".

Execute the "RID 0x114, offset 1536 (0x600), data length 2, read", the status of the correction table is received

- 0x0000 INL correction inactive
- 0x0F00 INL correction active

Execute the "RID 0x114, offset 1536 (0x600), data length 2, write, x data", the status of the correction table can be changed

- 0x0000 INL correction inactive
- 0x0F00 INL correction active

Example, read status correction table:

RID	Access	Offset (y/n)	Offset	Data length	R/W	Data
0x114	indirect	y	1536 (0x600)	2	R	--

Example, enable correction table:

RID	Access	Offset (y/n)	Offset	Data length	R/W	Data
0x114	indirect	y	1536 (0x600)	2	W	0F00

Edit correction table

The correction table, which is generated by the "accuracy calibration", can be read out value by value and modified.

The offsets for the several values are as followed:

	Byte 0 / Byte 1	Byte 2 / Byte 3	Byte 4 / Byte 5	Byte 6 / Byte 7
Offset 1537	Index 000	Index 001	Index 002	Index 003
Offset 1538	Index 004	Index 005	Index 006	Index 007
Offset 1539 .. Offset 1566	Index ...	Index ...	Index ...	Index ...
Offset 1567	Index 120	Index 121	Index 122	Index 123
Offset 1568	Index 124	Index 125	Index 126	Index 127



The values 513 .. 544 are 16 bit signed.

The resolution of the received values is in the raw resolution of the ENS35 / ENM35, which is 2²⁶. 1 digit = 0,019 angular sec.

With a "read" request, the values can be checked, with a "write" request, the values can be modified.

RID	Access	Offset (y/n)	Offset	Data length	R/W	Data
0x114	indirect	y	1537 (0x601) .. 1568 (0x620)	8	R/W	-- x

