5.17 Pole position identification

Overview

For synchronous motors, the pole position identification (PolID) determines the electrical absolute position that is required to determine the commutation angle (≙ pole position). The electrical absolute position is usually provided with absolute information by a mechanically or electrically calibrated encoder here.

Function description

> ⚠ **WARNING**
>
> **Unplanned motor motion when carrying out measurements at motors that are not braked**
>
> The measurement for unbraked motors can cause a motor movement with the specified current that can lead to death or severe injuries.
> - Ensure that nobody is in the danger zone and that the mechanical parts can move freely.

> ⚠ **WARNING**
>
> **Faulty safety functions with no pole position identification**
>
> If a PolID is not performed, correct functioning of the safety functions of the drive cannot be guaranteed. This can result in death or serious injury.
> - Carry out a PolID.

> ⚠ **WARNING**
>
> **Uncontrolled motor motion as a result of an incorrect control sense of the speed control loop**
>
> If a PolID was used to determine the commutation angle, then the commutation angle must be redetermined each time the control sense is changed. An incorrect commutation angle may result in uncontrollable motor movement which can cause death or serious injuries.
> - Check the commutation angle offset (F7966) after an actual value inversion and, if necessary, determine the offset again (p1990 = 1).

Applications

Pole position identification (PolID) is preferably used to determine the electrical absolute position or for electrical calibration (≙ determination of the commutation angle offset). It is necessary to determine the electrical absolute position in particular if there is not yet an absolute position when the drive is switched on.

Accordingly, we can distinguish between the following applications:

- **Determination of the commutation angle after POWER ON or encoder reset:**
  - You activate the function with p1982 = 1.
  - This function is used if the electrical absolute position required for the commutation is not present after a POWER ON or encoder reset. This is the case, for example, in motors with an incremental encoder without C/D track or an encoder with distance-coded zero marks. The commutation angle (≙ pole position) is determined using the function.
- **Determining the commutation angle offset:**
  - You activate the function with p1990 = 1.
  - This function is used when the electrical absolute position required for the commutation is present but not calibrated. This is the case, for example, with absolute encoders if an encoder replacement has been performed or a built-in motor with encoder has been installed.
    In this context, a built-in motor refers to a motor that is assembled from individual components (stator, rotor, etc.) and an encoder that is not mechanically calibrated.
    As an alternative to mechanical calibration, the absolute position can be calibrated using the commutation angle offset. In this case, the function identifies the commutation angle (≙ pole position) once and enters the commutation angle offset in p0431. No further PolID needs to be performed after the offset is saved.
  - On the other hand, the function is also used in motors with an incremental encoder with zero mark or with distance-coded zero marks. In these cases, the commutation angle (≙ pole position) is determined in relation to the zero mark.
    If p0404.15 = 1 (commutation with zero mark) is set, the commutation angle is determined from the zero mark position and the commutation angle offset after each PolID with p1982 = 1 and subsequent overtraveling of the zero mark.
  - You can find more information on determining the commutation angle offset in Chapter "Determining the commutation angle offset (Page 181)".
- **Plausibility check for encoders with absolute information:**
  - You activate the PolID with p1982 = 2.

Available procedures

The following procedures are available for pole position identification:

- **Saturation-based 1st + 2nd harmonics:**
  To set this procedure, set p1980 = 0.
- **Saturation-based 1st harmonic:**
  To set this procedure, set p1980 = 1.
- **Saturation-based 2-level:**
  To set this procedure, set p1980 = 4.
- **Motion-based:**
  To set this procedure, set p1980 = 10.
- **Elasticity-based:**
  To set this procedure, set p1980 = 20.

Determining the suitable method

On the basis of the following table, you can determine the PolID methods that are suitable for your drive:

	Saturation-based	Motion-based	Elasticity-based
Brake available	Possible	Not possible	Required
Motor can move freely	Possible	Required	Not possible
Motor has no iron	Not possible	Possible	Possible

Supplementary conditions

You can find more detailed information about the constraints that apply to the available process in Chapter "Pole position identification (Page 174)".

Encoder types

A PolID is not required for the following encoder properties:

- Absolute encoder (e.g. EnDat, DRIVE-CLiQ encoder)
- Encoder with C/D track and number of pole pairs ≤ 8
- Hall sensor
- Resolver with a multiple integer ratio between the motor pole pair number and the encoder pole pair number
- Incremental encoder with an integer ratio between the number of motor pole pairs and the number of encoder pulses

PolID on encoder replacement

An encoder replacement is automatically detected for encoders with electronic serial number and p1990 = 1 is set. This case is valid for all absolute encoders.

An encoder replacement is not automatically detected for encoders without electronic serial number (e.g. incremental encoders) or encoders that were delivered with a built-in Siemens motor. After an encoder replacement, p1990 = 1 needs to be set manually.

PolID with Siemens motors

When Siemens motors are used, the process is automatically set depending on the motor type being used. No further settings are necessary.

PolID for motors that are not listed

When third-party motors are used, the PolID needs to be set manually.

Procedure

Proceed as follows to perform a PolID:

1. Select a technique with p1980.
2. Set p1990 = 1 to activate the selected technique.
   The value in p1982 is not taken into account.

PolID failed

The PolID has failed if:

- The motor provides insufficient or no torque.
- The motor becomes hot too fast.
- A corresponding fault message is displayed.

Supplementary conditions

When selecting a suitable technique for the PolID, you must carefully observe and comply with the following notes and information.

Note

Selecting a suitable technique for 1FN3 linear motors

The saturation-based technique is the default setting for 1FN3 linear motors. For braked motors, this technique provides more accurate results than for unbraked motors. To achieve a higher identification accuracy, you must select either the motion-based or elasticity-based technique. Selecting the technique suitable for the particular application depends on the general mechanical conditions (e.g. friction situation, vertical axes, etc.).

Saturation-based PolID

The following notes and supplementary conditions apply to the saturation-based PolID:

- The technique can be performed for both braked and non-braked motors.
- The technique can only be performed for a speed setpoint = 0 or from standstill.
- In order to obtain meaningful measurement results, the specified currents (p0325, p0329) must be sufficiently high.
- For motors without iron, the pole position cannot be identified with the saturation-based PolID.
- For 1FN3 motors, it is not permissible to traverse with the 2nd harmonic (p1980 = 0, 4).
- With 1FK7 motors, a two-stage technique must not be used (p1980 = 4). The value in p0329, which is set automatically, must not be reduced.

Note

Inaccuracy when determining the commutation angle

If several 1FN3 linear motors are coupled together, and at the same time a saturation-based PolID is performed for the commutation (p1980 ≤ 4 and p1982 = 1), this can influence the DC link voltage. Fast current changes in the DC link cannot be completely compensated. In this case, the commutation angle is not determined precisely.

- If high precision is required, perform the PolIDs in succession. This can be achieved, for example, by enabling the individual drives one after the other (with a time offset).

Motion-based PolID

For the motion-based technique, the following notes and supplementary conditions apply:

- The motor must be free to move and must not be subject to external forces. The technique therefore **cannot** be performed for vertical axes.
- The technique can only be performed for a speed setpoint = 0 or from standstill.
- If there is a motor brake, it must be open (p1215 = 2).
- The specified current magnitude (p1993) must move the motor by a sufficient amount.
- A position sensor must be available and also activated.

Elasticity-based PolID

For the elasticity-based technique, the following notes and supplementary conditions apply:

- A brake must be available and must also be activated during the PolID. Either the drive controls the brake (p1215 = 1 or 3) or the brake is externally activated in advance of the PolID start and deactivated again after the operation.
- A position sensor must be available and also activated.

- Drive axis motion corresponds to the deflection (motion in the µm to mm range). Uncontrollable axis motion is completely ruled out **during** the measurement.

> ⚠ **WARNING**
>
> **Uncontrollable axis motion as a result of incorrect settings**
>
> With incorrect settings during the elasticity-based PolID, uncontrollable axis motion can occur when enabling the axis after the measuring procedure, which can cause death or severe injury.
>
> - Ensure that the settings in the context of this technique are correct.
> - Ensure that after completing the technique, the axis cannot move.

- Parameters p3090 to p3096 must be correctly set for a successful elasticity-based PolID. For a detailed description of the technique, see Chapter "Setting of the elasticity-based pole position identification (Page 184)".
The following table contains basic information on the relevant parameters:

Parameter	Designation	Information about parameterization
p3090	PolID elasticity-based configuration	The value "0" is preset in the parameter. For motors, where the brake is installed between the motor and encoder, an inversion may be required in order to take into account the relationship between the sign of the deflection and the torque or force. The inversion is set in bit 0 (p3090[0]).
p3091	PolID elasticity-based ramp time	The ramp time is preset with 250 ms. This value should only be changed if mechanical oscillations are present. Generally, mechanical oscillations occur if the ramp time is too short (< 250 ms).
p3092	PolID elasticity-based wait time	The wait time serves as buffer between the measurement operations. Set a wait time longer than 5 ms in order to make a clear distinction between the individual measuring operations.
p3093	PolID elasticity-based measurement count	We recommend you set 12 measurement steps to achieve a rugged and precise PolID. The precision and duration of the measurement increases proportionally with the number of measurement steps.
p3094	PolID elasticity-based deflection expected	The parameter setting depends heavily on the mechanical design and the drive braking force, and must therefore be set by the customer.
p3095	PolID elasticity-based deflection permitted	The maximum permissible deflection preset in the parameter is 1 degree or 1 mm.
p3096	PolID elasticity-based current	The parameter setting depends heavily on the mechanical design and the drive braking force, and must therefore be set by the customer.

Parameter (technique-dependent)

The table below gives you an overview of the important parameters depending on the PolID method selected:

Parameter	Compact information	Saturation-based	Motion-based	Elasticity-based
p0325[0...n]	Parameter is used to set the current for the 1st phase of the 2-stage technique. The current of the 2nd phase is set in p0329. The 2-stage technique is selected with p1980 = 4.	+	–	–
p0329[0...n]	Parameter is used to set the current for the PolID. For 2-stage techniques (p1980 = 4), then the current for the 2nd phase is set here. The current of the 1st phase is set in p0325.	+	–	–
p1980[0...n]	Set the required technique for the PolID using this parameter.	Value 0, 1 or 4	Value 10	Value 20
p1981[0...n]	Parameter is used to set the maximum distance (electrical angle) when executing the PolID.	+	+	–
p1982[0...n]	You determine the commutation angle or perform a plausibility check using this parameter.	+	+	+
p1983	Perform a PolID for test purposes using this parameter.	+	+	+
r1984	Indicates the angular difference between the actual electrical commutation angle and that determined from the PolID.	+	+	+
r1985	Indicates the current characteristic of the PolID for an elasticity-based technique.	–	–	+
r1986	Indicates the pole position curve of the saturation and elasticity-based PolID	+	–	+
r1987	Indicates the trigger curve of the PolID.	+	–	+
p1990	Parameter is used to determine the commutation angle offset for the encoder adjustment.	+	+	+
r1992.0...15	Display and BICO output for the diagnostics information of the PolID.	+	+	+
p1993[0...n]	Parameter is used to set the current for the motion-based PolID.	–	+	–
p1994[0...n]	Parameter is used to set the current rise time.	–	+	–
p1995[0...n]	Parameter is used to set the gain.	–	+	–
p1996[0...n]	Parameter is used to set the integral time.	–	+	–
p1997[0...n]	Parameter is used to set the smoothing time.	–	+	–
p3090[0...n]	Parameter is used to set the configuration for the elasticity-based PolID.	–	–	+
p3091[0...n]	Parameter is used to set the ramp time for the current increase.	–	–	+

Parameter	Compact information	Saturation-based	Motion-based	Elasticity-based
p3092[0...n]	Parameter is used to set the wait time between 2 measurements. The wait time between two measurements is necessary in order to avoid mechanical resonance effects.	–	–	+
p3093[0...n]	Parameter is used to set the number of measuring operations. The result becomes more accurate when the value is increased; however, the PolID takes longer.	–	–	+
p3094[0...n]	Parameter is used to set the expected deflection. The following setting is practical: p3094 < p3095.	–	–	+
p3095[0...n]	Parameter is used to set the permissible deflection. The following setting is practical: p3094 < p3095.	–	–	+
p3096[0...n]	Parameter is used to set the maximum permissible current. The following setting is practical: p3096 ≤ min (p0305, p0640, p0209).	–	–	+
r3097.0...31	Indicates the status of the elasticity-based PolID.	–	–	+
Marking: + = relevant, – = not relevant				

5.17.1 Determining the commutation angle offset

Overview

The function is used in the following cases:

- For single calibration of the pole position for absolute encoders
- For calibrating the zero mark position for fine synchronization

Procedure

Set p1990 = 1 to determine the commutation angle offset.

The determined offset is then entered in p0431.

Table 5-12 Mode of operation of p0431

	Incremental without zero mark	Incremental with one zero mark	Incremental with distance-coded zero marks	Absolute encoder
C/D track	Shifts the commutation with respect to the C/D track.	Shifts the commutation with respect to the C/D track and zero mark.	Currently not available.	Not permitted.
Hall sensor	Does not influence the hall sensor. **Note:** The hall sensor must be mechanically adjusted.	Does not influence the hall sensor. Shifts the commutation with respect to the zero mark.	Does not influence the hall sensor. Shifts the commutation with respect to the absolute position (after two zero marks have been passed).	Not permitted.
PolID	No effect	Shifts the commutation with respect to the zero mark.	Shifts the commutation with respect to the absolute position (after two zero marks have been passed).	Shifts the commutation with respect to the absolute position

Note

If a technique for the PolID is selected using p1980, and a catalog motor with factory adjusted encoder was not parameterized, when it is identified that an encoder has been replaced, then p1990 is automatically activated.

5.17.2 Fine synchronization

Overview

Fine synchronization prevents measurement scattering and allows additional testing of the determined pole position.

Suitable zero marks

- One zero mark in the complete traversing range
- One zero mark per mechanical revolution
- Distance-coded zero marks
- Equidistant zero marks:
  The ratio between the number of pole pairs and the number of equidistant zero marks per revolution or the ratio between the zero mark spacing and the pole pair width must be an integer.
  - Example of linear motor:
    If the pole pair width is 40 mm, the equidistant zero mark spacing must be an integer multiple (40, 80, 120, ... mm). In contrast, the zero mark spacing cannot be 20 mm.

Encoder with zero marks

If suitable zero marks are present and p0404.15 = 1 is set, the commutation angle is automatically synchronized from the position of the zero mark(s) and the commutation angle offset after overtraveling of the zero mark(s).

Requirement

- The zero mark(s) was/were calibrated mechanically or electrically.

Procedure

To perform the fine synchronization, proceed as follows:

1. Set p0404.15 = 1.
2. Set p1990 = 1.
3. To overtravel the zero mark(s), traverse the drive by entering a valid speed setpoint.

The commutation angle offset is determined after the PolID and the overtravel of the zero mark(s) and entered in p0431.

Encoders without zero marks

In motor-encoder configurations that cannot meet the above-specified requirements relating to zero marks, the zero mark used for the reference point approach can be used as zero mark for the fine synchronization.

Requirement

- The zero mark(s) was/were calibrated mechanically or electrically.

Procedure

Proceed as follows to determine the zero mark for the fine synchronization:

1. Set the "Commutation with selected zero mark" mode in p0430.24.
   The following responses are triggered:
   - Via the PROFIdrive encoder interface, the drive receives the request for a reference mark search.
   - Together with the Sensor Module, the drive determines the reference mark as a result of the parameterization.
   - The drive provides the reference mark position via the PROFIdrive encoder interface.
   - The drive transfers the same position to the Sensor Module.
   - The Sensor Module corrects the commutation angle (fine synchronization).
2. Set p1990 = 1 to determine the commutation angle offset.

5.17.3 Setting of the elasticity-based pole position identification

Overview

The technique described in the following is an example of the setting of the elasticity-based pole position identification (PolID) for linear motors and rotary motors.

- You can parameterize this technique in the commissioning tool.
- The following example shows the parameterization in STARTER.

Also observe the notes and information on this technique in Chapter "Pole position identification (Page 174)".

Requirements

The following requirements must be satisfied in order to be able to perform the elasticity-based PolID.

- Motor, encoder and brake control have been correctly parameterized.

Procedure

⚠ WARNING

Uncontrollable axis motion as a result of incorrect settings

With incorrect settings during the elasticity-based PolID, uncontrollable axis motion can occur when enabling the axis after the measuring procedure, which can cause death or severe injury.

- Ensure that the settings in the context of this technique are correct.
- Ensure that after completing the technique, the axis cannot move.

Proceed as follows to set the elasticity-based PolID.

1. Open the STARTER commissioning tool.
2. Create a new project and select the components in accordance with your drive configuration.
   OR
   Call the already saved project in which you want to perform the elasticity-based PolID.
3. Click the  button ("Connect to selected target devices") to connect to the target device.
4. Call the expert list for the configured drive.
5. Click the  button ("Device trace/function generator") to open the device trace in STARTER.
   The device trace opens.

6. Select the following signals of the configured drive in the device trace.
   – r0076: Current actual value field-generating
   – r0479[0]: Diagnostics encoder position actual value

No.	Active	Signal	Comment	Color
1	☑	LIN.r76	LIN.r76: Current actual value field-generating	
2	☑	LIN.r479[0]	LIN.r479[0]: Diagnostics encoder position actual value Gn_XIST1, Encoder 1	
3	☐			
4	☐			
5	☐			
6	☐			
7	☐			
8	☐			

Figure 5-22 Device trace: Select signals

The following figure shows further settings in the device trace. In order to obtain good, useful measurement results, we recommend that you set the displayed values.

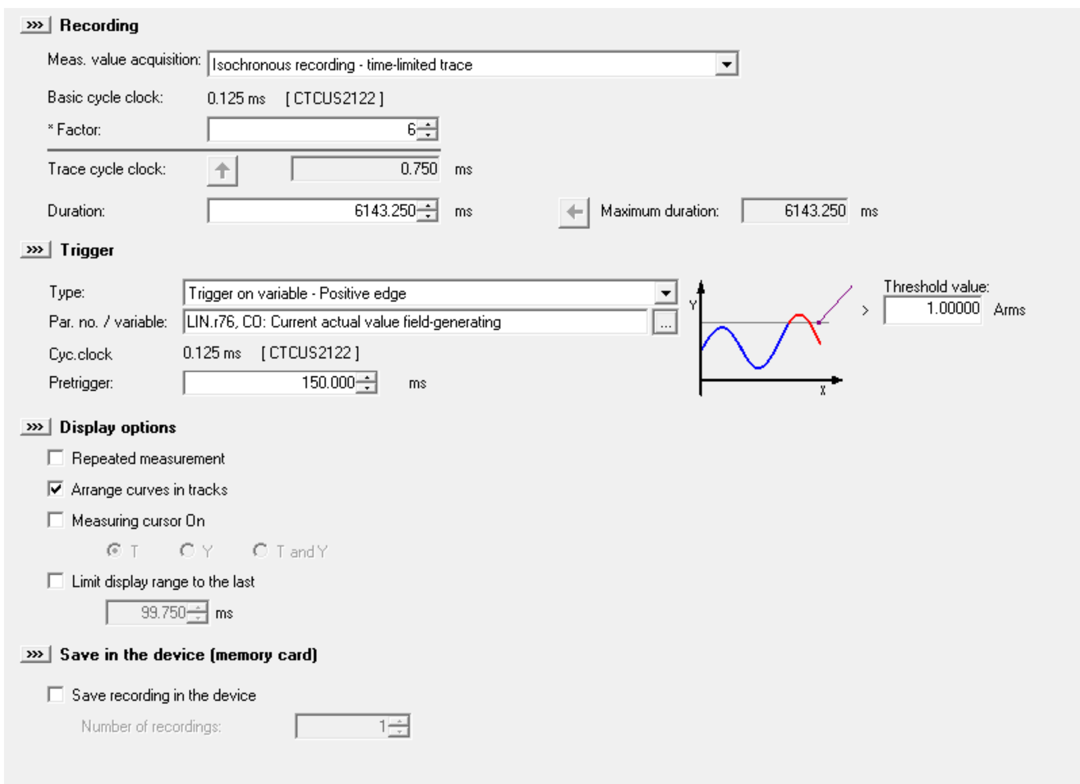


Figure 5-23 Device trace: Recommended settings

7. Set the rated motor current in parameter p3096[0] (PolID elasticity-based current).

Note

The rated motor current is displayed in parameter p0305[0].

8. Set the value "20" in parameter p1980[0] (PolID technique)

9. Set the value "1" in parameter p1982[0] (PolID selection).
   You have now activated the elasticity-based PolID.

   Note

   Setting of further parameters

   Further parameters do not have to be set. Leave the other parameters in the factory setting.

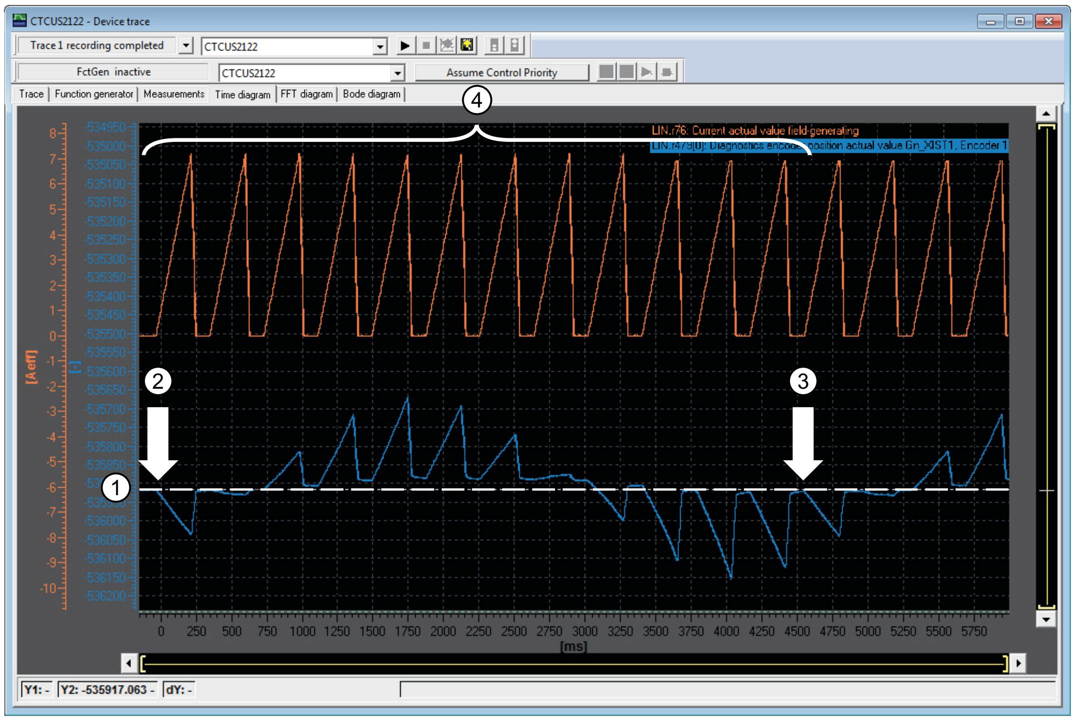
10. Click the  button ("Start trace") to start the trace.
11. Enable the drive to start the measurement.
    The measurement result is displayed.

    Note

    Enabling the drive via the control panel

    An alarm/message may appear when enabling the drive via the control panel.

12. Compare the deflection at the starting point of the measurement (2) with the deflection at the end point of the measurement (3).
    The following figure shows the measurement result. A guide line (1) is shown for the optical alignment and aligned as reference line at the starting point (2) of the measurement.



Signal (red/top): Measuring current

Signal (blue/bottom): Deflection

① Guide line

② Starting point of the measurement

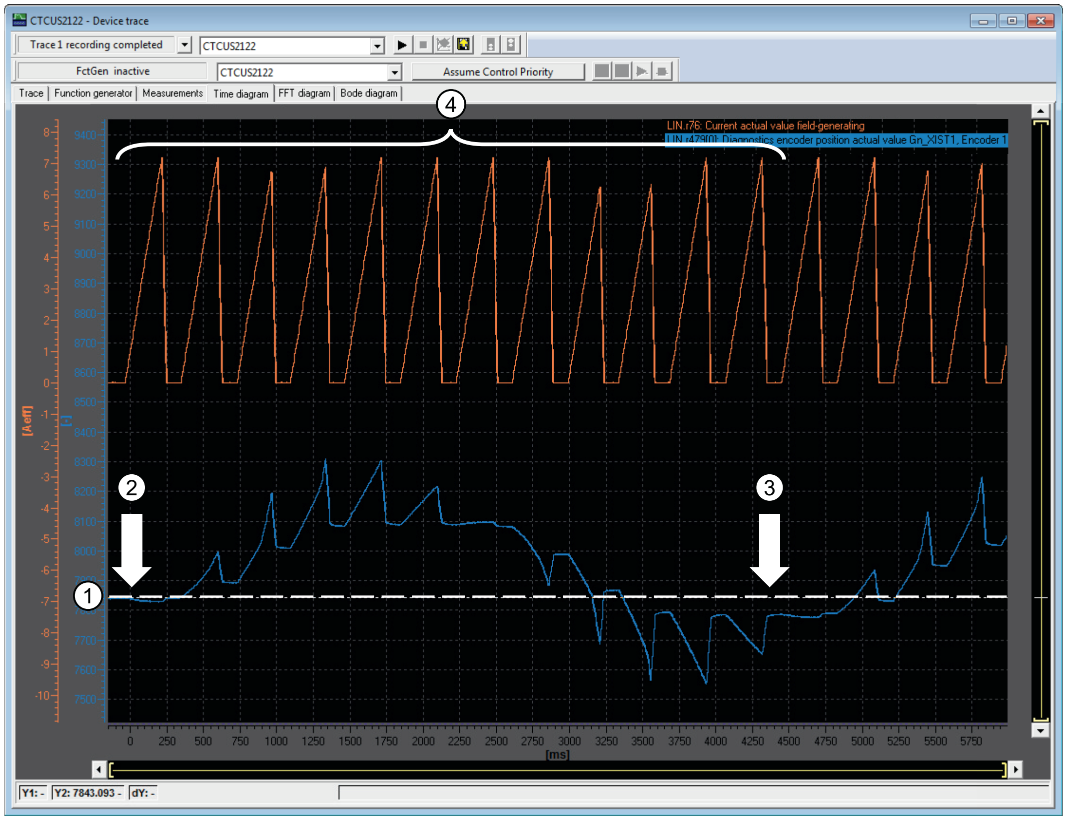
③ End point of the measurement

④ Amplitudes of measuring currents 1 to 12 (p3093)

Figure 5-24 Measurement result: Determined deflection

- Result 1: You have set parameter p3096[0] correctly when the deflection at the starting point of the measurement (2) corresponds to the deflection at the end point of the measurement (3).
- Result 2: The holding brake is not strong enough when the deflection at the starting point of the measurement (2) differs significantly from the deflection at the end point of the measurement (3). In this case, we recommend that you reduce the measuring current step-by-step until the deflection at the starting point of the measurement corresponds to the deflection at the end point of the measurement, or approximately. Only continue with the next step when this has been ensured.

The following figure shows an example of the signal curve of the deflection when the brake is too weak.



Signal (red/top): Measuring current

Signal (blue/bottom): Deflection

① Guide line

② Starting point of the measurement

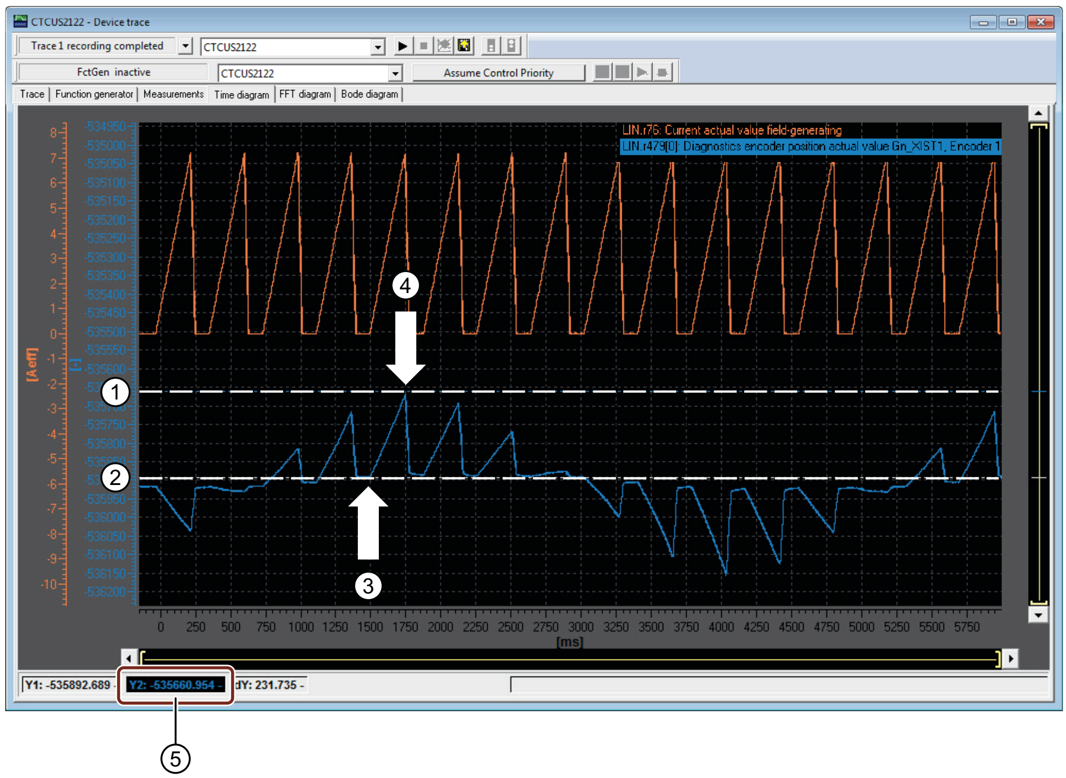
③ End point of the measurement

④ Amplitudes of measuring currents 1 to 12 (p3093)

Figure 5-25 Measurement result: Brake too weak

13. Compare the height of the deflection amplitudes in both directions and determine optically the highest amplitude in the measurement result.

14. Determine the stroke of the maximum deflection. The maximum deflection corresponds to the highest deflection (peak) in the measurement result. The stroke corresponds to the calculated difference between the lowest (3) and the highest point (4) of the deflection amplitude.
    – Tip: Insert a guide line (1) and move it to the top of the highest deflection. Insert a second guide line (2) and move it to the zero point of the highest deflection.



① Guide line 1

② Guide line 2

③ Lowest point of the deflection amplitude

④ Highest point of the deflection amplitude

⑤ Display of the difference

Figure 5-26 Determining the highest deflection amplitude

The value calculated as the difference between the lowest (3) and the highest point (4) of the deflection amplitude is shown in the display bar (5) of the trace. The displayed value corresponds to the stroke of the deflection amplitude.

15. To calculate the value for parameter p3094[0] (PolID elasticity-based deflection expected), set the determined value (difference) in the appropriate formula.
    – For linear motors:

$$p3094 = \frac{\text{Difference}}{3} \cdot \frac{p407}{(10^9)} \text{ [mm]}$$

    – For rotary motors:

$$p3094 = \frac{\text{Difference}}{3} \cdot \frac{360}{p408} \text{ [°]}$$

16. Enter the calculated value in the expert list in parameter p3094[0] (PolID elasticity-based deflection expected) of the configured drive.
17. Acknowledge the fault.
    This completes the configuration.

18. To check the result, restart the trace and enable the configured drive.
    The measurement result is displayed.

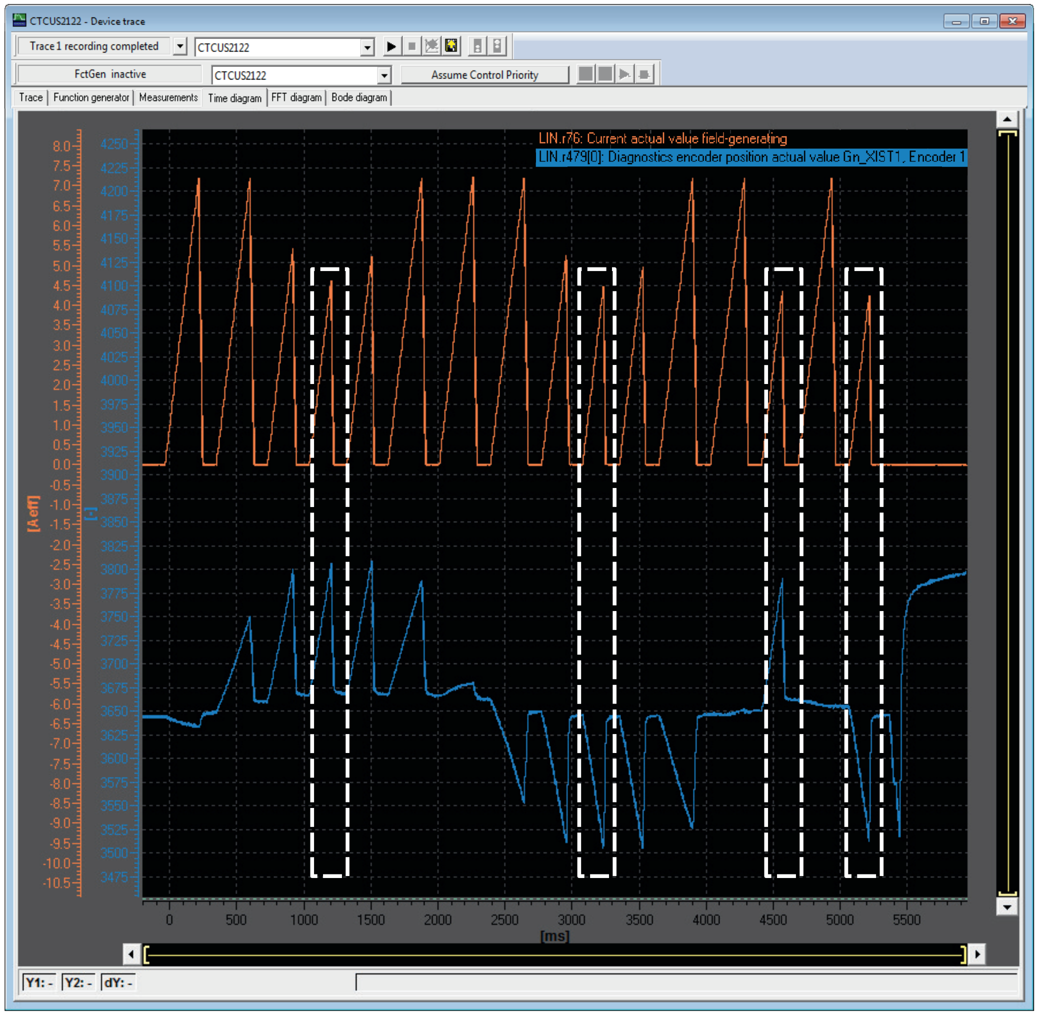


Figure 5-27 Measurement result after the configuration

19. Check the measurement results.
    Based on the following questions, you can check the validity of the measurement in relation to the determination of the PolID.
    - Is a fault present for the configured/selected drive after the last measurement?

      Note

      Possible causes and remedies can be found in the help of the relevant alarm.

    - Were different measuring currents taken into account during the measurement?

      Note

      Different measuring currents are indicated by the varying heights of the current amplitudes (wave form of the curve) in the measurement result.

    - Does the lowest current amplitude of the first 12 measuring points in the measurement result correspond approximately to the maximum deflection?

      Note

      The measurement is made up of 12 measuring points (p3093) to determine the deflection and 4 control measuring points for the plausibility check.

    - Do the last 4 measuring points comprise 2 maximum currents, 2 minimum currents, 2 minimum deflections and 2 maximum deflections in different directions?
20. If you can answer all questions with **YES**, then the technique for the elasticity-based PolID has been set correctly.
    The pole position of the drive has been determined.
21. Click the button ("Copy RAM to ROM") to save the parameter setting in the drive and, if required, in your project.
22. If you had to answer one of the questions with **NO**, then the technique for the elasticity-based PolID is faulty or has failed.
    To ensure that all values have been determined correctly and entered in the parameters, repeat the technique.

    Note

    Setting of further parameters

    If required, change the values in parameters p3090 to p3096 when repeating the technique. Check the measurement results.

    Also observe all steps of the procedure for the elasticity-based PolID.
    If repeated attempts to perform the technique fail, please contact the Siemens Support (https://support.industry.siemens.com/cs/ww/en/).

Overview of important parameters (see SINAMICS S120/S150 List Manual)

- p0325[0...n] Motor pole position identification current 1st phase
- p0329[0...n] Motor pole position identification current
- p0404[0...n] Encoder configuration active

- p0430[0...n] Sensor Module configuration
- p0431[0...n] Commutation angle offset
- p0437[0...n] Sensor Module extended configuration
- r0458 Sensor Module properties
- r0459 Sensor Module extended properties
- p0640[0...n] Current limit
- p1082[0...n] Maximum speed
- p1215 Motor holding brake configuration
- p1980[0...n] PolID procedure
- p1981[0...n] PolID maximum distance
- p1982[0...n] PolID selection
- p1983 PolID test
- r1984 PolID angular difference
- r1985 PolID saturation curve
- r1987 PolID trigger curve
- p1990 Encoder adjustment, determine commutation angle offset
- p1991[0...n] Motor changeover, commutation angle offset
- r1992.0...15 CO/BO: PolID diagnostics
- p1993[0...n] PolID motion-based current
- p1994[0...n] PolID motion-based rise time
- p1995[0...n] PolID motion-based gain
- p1996[0...n] PolID motion-based integral time
- p1997[0...n] PolID motion-based smoothing time
- p3090[0...n] PolID elasticity-based configuration
- p3091[0...n] PolID elasticity-based ramp time
- p3092[0...n] PolID elasticity-based wait time
- p3093[0...n] PolID elasticity-based measurement count
- p3094[0...n] PolID elasticity-based deflection expected
- p3095[0...n] PolID elasticity-based deflection permitted
- p3096[0...n] PolID elasticity-based current
- r3097.0...31 BO: Pole ID elasticity-based status