Position Settling Analysis

Application Note 150

The position settling analysis features, provide simple measurement tools, to analyze the repeatability of a motion system. Using it can help to detect system changes. Such system changes can happen by aging effects, a mechanical or electrical damage or simply modifications in software or parameters.

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1 Introduction

In firmware version ≥4.17 we introduce on-board features for position settling analysis. These features are configured with a set of new *Parameters*, in:

Axes[].Parameters.PositionController.Analysis

As soon as a Method is configured, the calculation runs in the background and results are available in:

Axes[].Signals.PositionController.Analysis

Document AN150_PositionSettlingAnalysis_EP
Version 004, 2023-08-10
Source Q:\doc\ApplicationNotes\
Destination T:\Doc\ApplicationNotes
Owner sm

2 Analysis Methods

Currently, the following analysis methods are implemented. In addition to the Result register, the register Signals.PositionController.Analysis.Done, indicates if an analysis is running (False), or the result is ready (True).

The below analyses are triggered as follows, except the *Standard Deviation* method:

- The path planner state changing to *Standstill*,
- and by a value change in the register Axes[].Commands.CurrentController.InjectedIq

Accordingly, an axis is analyzed regarding reference tracking or disturbance rejection.

Note Each trigger restarts the analysis. If an application continuously sets InjectedIq, i.e. cogging compensation with *Tama*, then this feature cannot be used.

2.1 Standard Deviation

Calculates the standard deviation and averages over Time and updates with Time.

Parameters:

- PositionController.Analysis.Method = StandardDeviation
- PositionController.Analysis.Time = Time period to average.

Result in Signals.PositionController.Analysis.Result:

$$StandardDeviation = \sqrt{\frac{\int_0^{Time} err^2 dt}{Time}}$$

2.2 Settling Time

The *SettlingTime* is the duration from the end of a move until the position error is within the Window for a defined Time. See Figure 1 for the visual definition of the parameters and the result.

Parameters:

- PositionController.Analysis.Method = SettlingTime
- PositionController.Analysis.Time = Minimum in-window time for a valid measurement
- PositionController.Analysis.Window = The window size (error band = 2 * window)

Result:

Signals.PositionController.Analysis.Result = Settling time for the last move, measured from the end of the trajectory.

2.3 Move and Settling Time

The result is the duration from the start of a move, until the position error is within the Window for a defined Time.

Parameters:

- PositionController.Analysis.Method = MoveAndSettlingTime
- PositionController.Analysis.Time = Minimum in-window time for a valid measurement
- PositionController.Analysis.Window = The window size (error band = 2 * window)

Result:

Signals.PositionController.Analysis.Result = Settling time for the last move, measured from the start of the trajectory.

The move time while following a trajectory is available at Axes[].Signals.PathPlanner.MoveDuration.

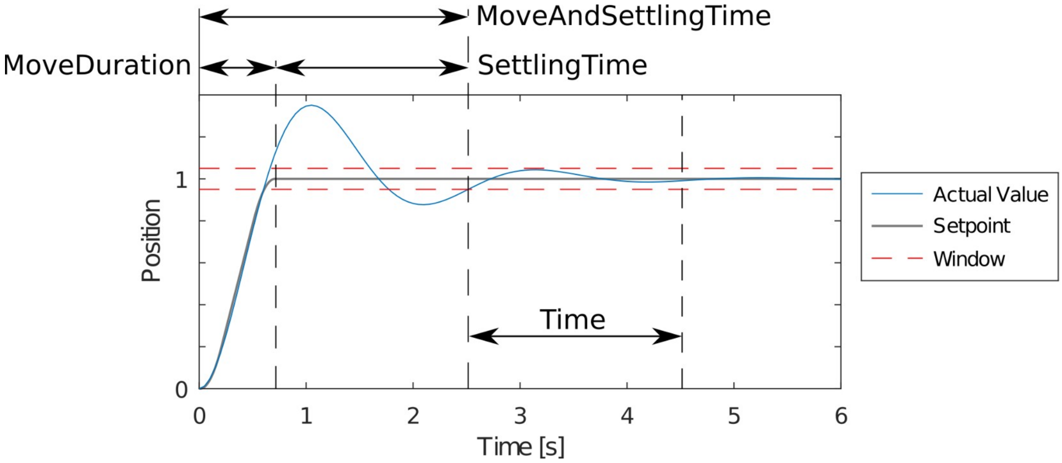


Figure 1: Visualized Move and Settling modes

2.4 ISE

The result of the *ISE* (*Integral Square Error*) calculation, for the duration Time, after the end of a move (path planner trajectory).

Parameters:

- PositionController.Analysis.Method = ISE
- PositionController.Analysis.Time = Time period for calculation.

Result in Signals.PositionController.Analysis.Result:

$$ISE=\sqrt{\frac{\int_0^{Time} err^2 dt}{Time}}$$

2.5 ITSE

The result of the *ITSE* (*Integral time Squared Error*) calculation, over the duration Time**,** after the end of the move (path planner trajectory).

Parameters:

- PositionController.Analysis.Method = ITSE
- PositionController.Analysis.Time = Time period for calculation.

Result in Signals.PositionController.Analysis.Result:

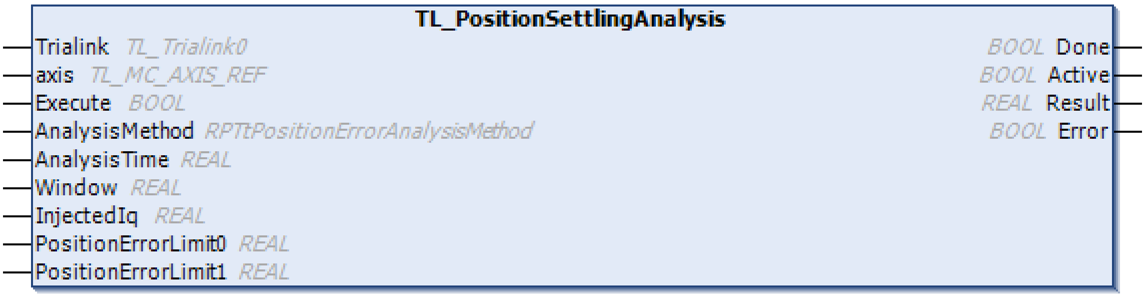
$$ITSE=\sqrt{\frac{2\int_{0}^{Time} t\cdot err^{2}\,dt}{Time^{2}}}$$

3 TwinCAT Function Block

A *Function Block (FB)* is available for ease of use of the analysis feature from *TwinCAT*.

- *Tria-Link*: `TL_PositionSettlingAnalysis`
- *EtherCAT*: `TE_PositionSettlingAnalysis`

The *FB* must be triggered with a positive edge on Execute. Output Active indicates (TRUE) that the analysis parameters are active. The Done output is TRUE, when a new Result is available. Error becomes TRUE if a timeout occurs. The timeout duration is at least the DEFAULT_ADS_TIMEOUT (global constant, set to 5 seconds) plus the configured AnalysisTime. For external triggers (InjectedIq = 0) 2x the DEFAULT_ADS_TIMEOUT applies. A new measurement result is expected within this time.



TL_PositionSettlingAnalysis

Trialink *TL_Trialink0*	*BOOL* Done
axis *TL_MC_AXIS_REF*	*BOOL* Active
Execute *BOOL*	*REAL* Result
AnalysisMethod *RPTtPositionErrorAnalysisMethod*	*BOOL* Error
AnalysisTime *REAL*	
Window *REAL*	
InjectedIq *REAL*	
PositionErrorLimit0 *REAL*	
PositionErrorLimit1 *REAL*	

Figure 2: FB for position settling analysis (Tria-Link)

The analysis parameters must be set according to the analysis method used and considering the axis/application limits:

- AnalysisMethod to choose the method to be used, see also chapter 2.
- AnalysisTime to set the characteristic time for analysis in [s].
- Window to set the size (error band = 2 * window) in [drive units]
- InjectedIq to set the current in [A] added to the position controller output during measuring (will be set if value ≠ 0 and set back to 0 after measuring)
- PositionErrorLimit0 to set the position error limit of Controller 0 in [drive units] (will be set if value ≠ 0 and set back to the previous value)
- PositionErrorLimit1 to set the position error limit of Controller 1 in [drive units] (will be set if value ≠ 0 and set back to the previous value)

Note The values InjectedIq and PositionErrorLimit are changed during the measurement if their values ≠ 0. If InjectedIq = 0, the FB waits for an external trigger, e.g. Standstill or change of InjectedIq (except the *Standard Deviation* method). Both InjectedIq and PositionErrorLimit will be set back at the end of measuring.

3.1 Example

An example can be found on:

- www.triamec.com > Products > Software > Beckhoff-TwinCAT Integration > Example with Tria-Link and NC

Revision History

Version	Date	Editor	Comment
001	2023-03-14	sm	Document Creation
002	2023-06-14	sm	Add trigger variant InjectedIq.
003	2023-06-16	sm	Explicit trigger declaration, excluding Standard Deviation since fw 4.19
004	2023-08-10	rb	Function Block PositionSettlingAnalysis

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