FAQ about Drive Technology

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Technology CPUs
FAQ

Setting PROFIBUS Cycle, Position Control Cycle and Interpolation Cycle

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Question

Technology CPUs: What is the correlation between PROFIBUS cycle, position control cycle and interpolation cycle?

Answer

The correlation of the cycle rates will be explained in the following.

1 Correlation between PROFIBUS Cycle, Position Control Cycle and Interpolation Cycle

1.1 Cycle times and accuracy

One of the most important questions regarding positioning processes is the accuracy with which a positioning process can be performed in a machine. If only the control section is considered, it is difficult to answer this question since the selected motors and encoders, as well as mechanical conditions of the specific machine play an important role.

However, the accuracy is related to the cycle time in the controller with which control processes are calculated. The shorter the cycle time of the controller the more often the setpoints are adapted in the control algorithm via the actual values of the machine or of the axes. Disturbances at the machine axes, e.g. inertial forces or friction, can be corrected quicker by the control system if the cycle times are shorter.

The setting and optimization of the system cycle parameters consequently has a direct effect on the performance of the machine and this fact should already be considered during planning and commissioning. The shorter the system cycle parameters are set the better the performance of the Technology CPU 317T-2 DP can be used. The accuracy which can be achieved and the response time of the CPU to disturbances are increased.

1.2 Technological functions

The technological functions are functions which expand the SIMATIC CPU by MotionControl applications, i.e. drives can be controlled via PROFIBUS.

An equidistant PROFIBUS (PROFIBUS DP(Drive)) is used for the drives. This enables clock-synchronized operation of the integrated technology of the controller, PROFIBUS and all connected drives, i.e. the clock cycles of all devices connected to the bus start at the same time.

This clock synchronism enables to use centralized positioning control for the drives despite a distributed automation structure.

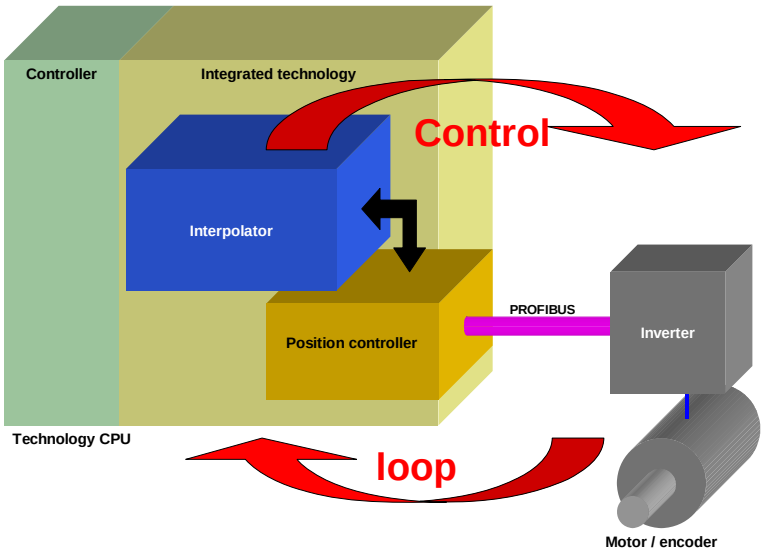
1.3 PROFIBUS cycle, position control cycle and interpolation cycle

The main task of the Technology CPU 317T-2 DP is the open-loop control or the closed-loop control of motion processes via the drive units connected to the CPU.

When connecting a drive to the Technology CPU 317T-2 DP, a control loop is produced between the drive and the position controller contained in the CPU. The position controller receives all necessary input values from the

interpolator[1] which generates the setpoints for the motion control and which is also part of the technology section of the CPU 317T-2 DP.

Figure 1-1 Scheme of the system structure



Each element of this control loop, e.g. Profibus, position controller and interpolator, can be individually set to a specific cycle rate within which the computing processes can be performed in this control loop.

1.3.1 Display of the different cycle types

The following cycle types can be influenced in the Technology CPU 317T-2 DP:

Profibus cycle (DP cycle)

The PROFIBUS cycle or DP cycle is the main time base and configured as master cycle of the Technology CPU 317T-2 DP. All other cycles are defined as multiples of the PROFIBUS cycle.

The PROFIBUS cycle is used to ensure an equidistant data transfer between the controller and all connected drives. All drives are set to the same cycle times, i.e. the processing times are synchronized. This enables clock-synchronized position control also on distributed drives.

Position control cycle (servo cycle)

The position controller monitors and influences the position of the individual axes. The position setpoints for the axes are output in the position control cycle, also referred to as servo cycle. The position control loop is used to react to errors and deviations of the axes from the set positions;

[1] The interpolator described here generates the setpoint values for the position controllers of the connected axes and is not related to the interpolation of cam discs, which are initiated by a PLCopen-FB. However, it uses the the fully interpolated cam discs during setpoint generation.

consequently the cycle time of the position controller directly affects the accuracy of the axes. A shorter cycle time increases the speed of response to position changes. Since the position control loop is closed via PROFIBUS, the minimum position control cycle cannot be shorter than the PROFIBUS cycle, since the controller in the control section can only be supplied with new information during this period of time.

Interpolation cycle (IPO cycle)

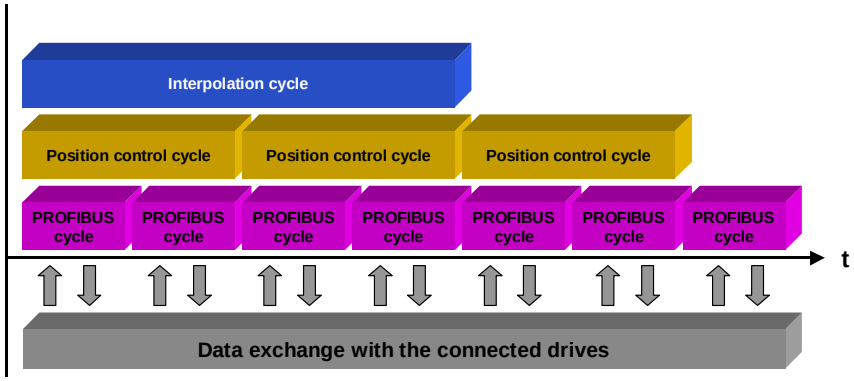
In the interpolation cycle, also referred to as IPO cycle, the interpolator of the controller calculates and provides the input values for the position controller. The interpolator separates the motion and positioning processes into individual steps and supplies these steps to the position controller as setpoints. Since this information can be transferred to the drives of the axes only in the position control cycle, the selected interpolation cycle must not be smaller than the position control cycle.

1.3.2 Interdependence between the individual cycle types

The following figure illustrates the interdependence between the individual cycle rates.

The PROFIBUS cycle is defined as master cycle. The position control cycle is set as integer multiple of the PROFIBUS cycle. The interpolation cycle is set as integer multiple of the position control cycle.

Figure 1-2 Classification of the cycle dependencies



The dependencies of the individual cycles are listed in the following table:

Table 1-1 Setting options of the system cycles

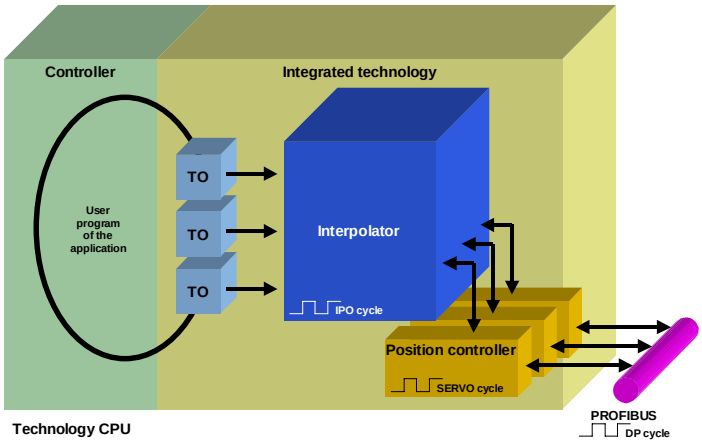
Cycle	Range
PROFIBUS cycle	Preset in HW Config in the range of 1.0...125.0 ms at steps of 0.125 ms. The PROFIBUS cycle is the master cycle for all other cycle rates.
Position control cycle	1- to 2-times the PROFIBUS cycle
Interpolation cycle	1- to 6-times the position control cycle

A short position control cycle (servo cycle) improves the accuracy of the machine since errors and influences from outside can be compensated quicker by the controller. The selection of a short position control cycle improves the machine's reaction to disturbances.

1.3.3 Utilization of the set cycle rates – task runtime

The degree of utilization of the defined cycle rates, in this document referred to as task runtime, is influenced by the number of connected axes (PROFIBUS cycle and position control cycle) and by the initiated technological functions (interpolation cycle).

Figure 1-3 Load of the individual objects of the control loop



The cycle rate is set during configuring the controller.

The task runtime cannot be preset or defined through parameters, it results from the tasks configured for the integrated technology. It can only be determined by measurements.

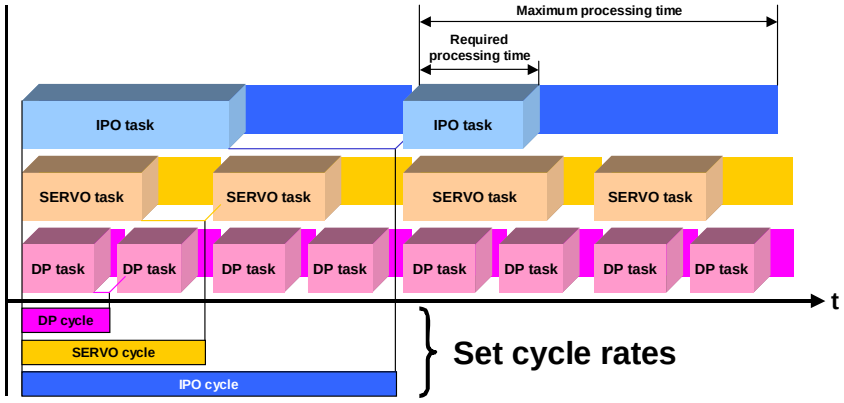
For this reason, the task runtimes for interpolator or position controller indicate the actual load of the integrated technology of the CPU 317T-2 DP caused by initiated technology objects or connected axes.

Influencing variables of the task runtimes

The more axes are connected to the Technology CPU 317T-2 DP the more position control loops have to be calculated in the defined period of time of the position control cycle. This causes an increase of the task runtime of the position controller for each axis, the servo task.

The number of the technology objects (TOs) simultaneously initiated by the user program which are already being calculated also influences the load of the interpolator. Accordingly, an increased number of technology objects to be processed by the interpolator also increases the task runtime of the interpolator, the IPO task, and consequently its load.

Figure 1-4 Correlation between cycle rate and task runtime



The reasons listed above show that the task runtimes within the individual cycles and thus the loads of the control loop objects are subject to variation. While the variations of DP and servo task are quite small –due to the fact that the number of connected axes does not change – the IPO task can vary in a large range. This rather large variation range is caused by the not statically defined number of simultaneous jobs to the technology objects of the CPU 317T-2 DP.

To ensure error-free operation with regard to the system cycles, the following has to apply: It must be possible to process the task runtime caused by the technology objects and axes of the application within the defined cycle time.

Utilization of the cycle by the task runtime in percent

The degree of utilization of the cycle in percent describes the relation between the defined cycle time and the task runtime required by the process:

$$\text{Utilization}\,[\%] = \frac{\text{Task runtime}\,[\text{ms}]}{\text{Cycle time}\,[\text{ms}]} \cdot 100\%$$

To provide sufficient safety margins during operation of the Technology CPU 317T-2 DP, a specific percentage of cycle utilization should not be exceeded.

Maximum utilization of the cycle rate by the task runtime

If the task runtime exceeds the selected cycle rate, the CPU goes to **Stop**. If this is the case, it is required to configure a longer cycle time in the controller. Subsequently, higher computing time resources are available for controller data and additional calculations, such as cam disc interpolation or synchronous operation. This ensures that errors at the CPU caused by overload (exceeding the cycle rate) are avoided.

Note

To ensure trouble-free operation of the Technology CPU 317T-2 DP, the cycle rates for DP, SERVO and IPO cycle must be selected in such a way that the occurring maximum task runtime does not exceed the set cycle time.

Practical experience has shown that it is advisable to configure the cycle time in such a way that the **maximum task runtime** does not exceed **70% of the set cycle time**.

If the maximum utilization of the cycle rate is less than 50% of the set cycle time, you should try to reduce the set cycle time so as to avoid that parts of the performance potential of the Technology CPU 317T-2 DP remain unused.

2 Setting the System Cycle Parameters

Before the optimum setting for the system cycle parameters can be determined, the CPU cycle rates must be set in the configuration tools HW Config and S7T-Config.

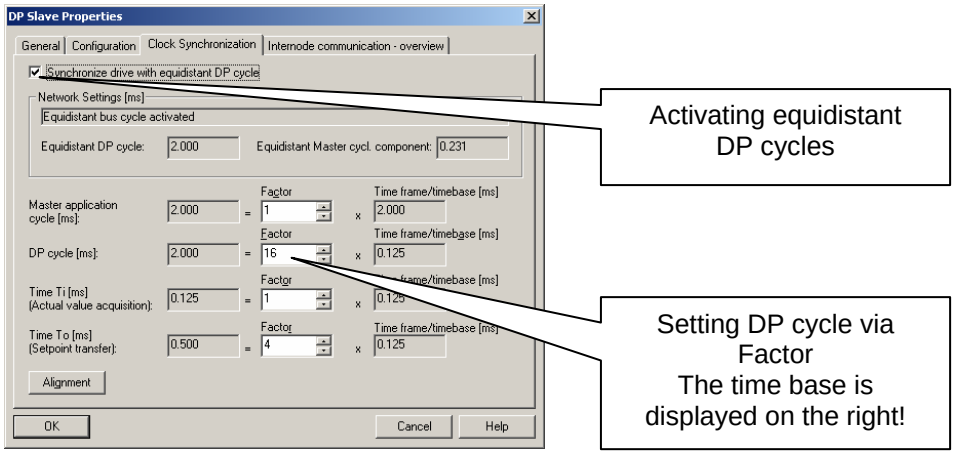
2.1 Selecting the DP cycle in the HW Config configuration tool

The Profibus cycle (DP cycle) is the master cycle of the MotionControl application and has to be set in the HW Config configuration tool of the Step7 project.

Double-clicking the corresponding drive (e.g. SIMODRIVE) in HW Config opens a dialog box in which the drive properties can be set. Select the **Clock Synchronization** tab to set the DP cycle for equidistant DP cycles.

Clicking the **Alignment** button enables to set other possibly connected drives on the same Profibus configured in HW Config to the same DP cycle without having to repeat the settings for each drive.

Figure 2-1 Setting the Profibus cycle (DP cycle)



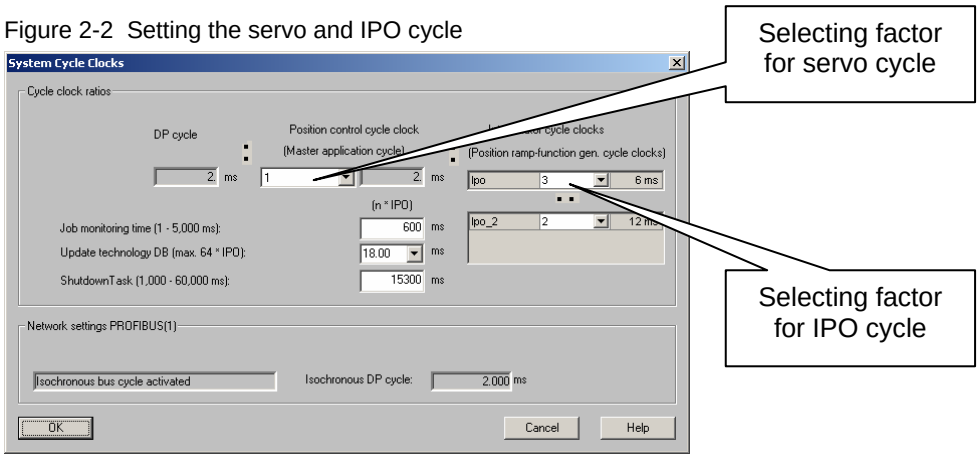
After successful setting of the cycle rate, the changed hardware configuration has to be loaded to the CPU.

2.2 Setting the factors for servo and IPO cycle in S7T-Config

If the DP cycle has been set as master cycle, servo and IPO cycle can be selected as integer multiples of the DP cycle in the S7T-Config configuration tool.

In the S7T-Config menu, the properties sheet can be opened via by selecting the menu items **Target System** and **Set System Cycle Clocks...**

Figure 2-2 Setting the servo and IPO cycle



The lists for setting the factors of the servo and IPO cycle only show the factors permissible for the current configuration.

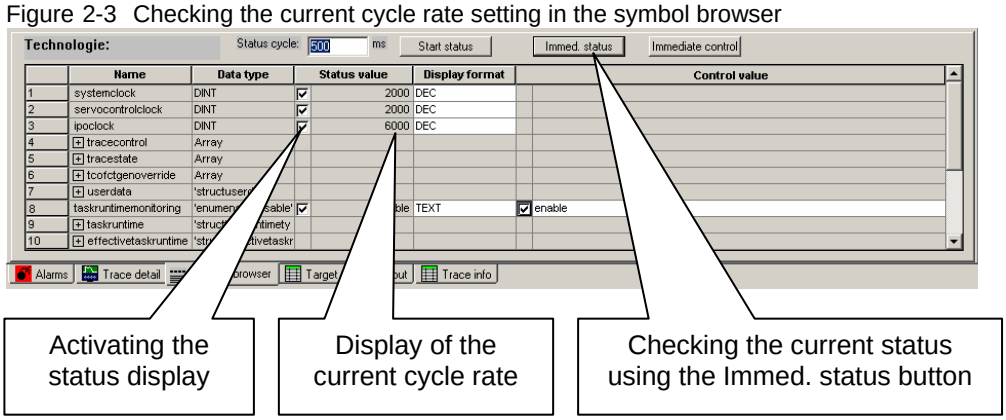
The set cycle rate in milliseconds is displayed in the box on the right of the factor.

After successful setting of the cycle rate, the changed hardware configuration has to be loaded to the CPU.

Checking the set cycle rates in the symbol browser

The active cycle rates currently set in the CPU can be checked via the symbol browser of the S7T-Config configuration tool.

Figure 2-3 Checking the current cycle rate setting in the symbol browser



Before the set values can be checked by clicking the **Immed. status** button, it is required to activate the display of the cycle rates in the checkboxes.