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.Position control

.General information

In the "position control" mode and "position control drive-controlled" mode, a cyclic position command value is made available to the drive in the NC cycle time. In the case of "position control drive-controlled", it is made sure drive-internally that, when the operation mode is changed, the transition is carried out in a synchronized way, even if the command value changes abruptly. As necessary, the command values are filtered in the drive (jerk filter and anti-vibration filter), and then fine-interpolated to the position controller cycle before they are transmitted to the position controller.

The axis control word specifies which actual position value (encoder 1, encoder 2, hybrid actual position value) is used for control and if control is lagless or with lag error.

To minimize the lag error, variable acceleration feedforward is available in addition to variable velocity feedforward.

Acceleration feedforward can also be preset externally via a control, and variable torque/force feedforward can thereby be implemented.

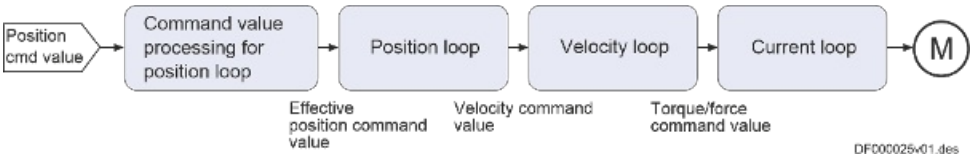

Fig. 254: "Position control with cyclic command value input" block diagram

.Commissioning

In the dialog of the ctrlX DRIVE Engineering commissioning tool, the "position control" / "position control drive-controlled" mode can be configured.

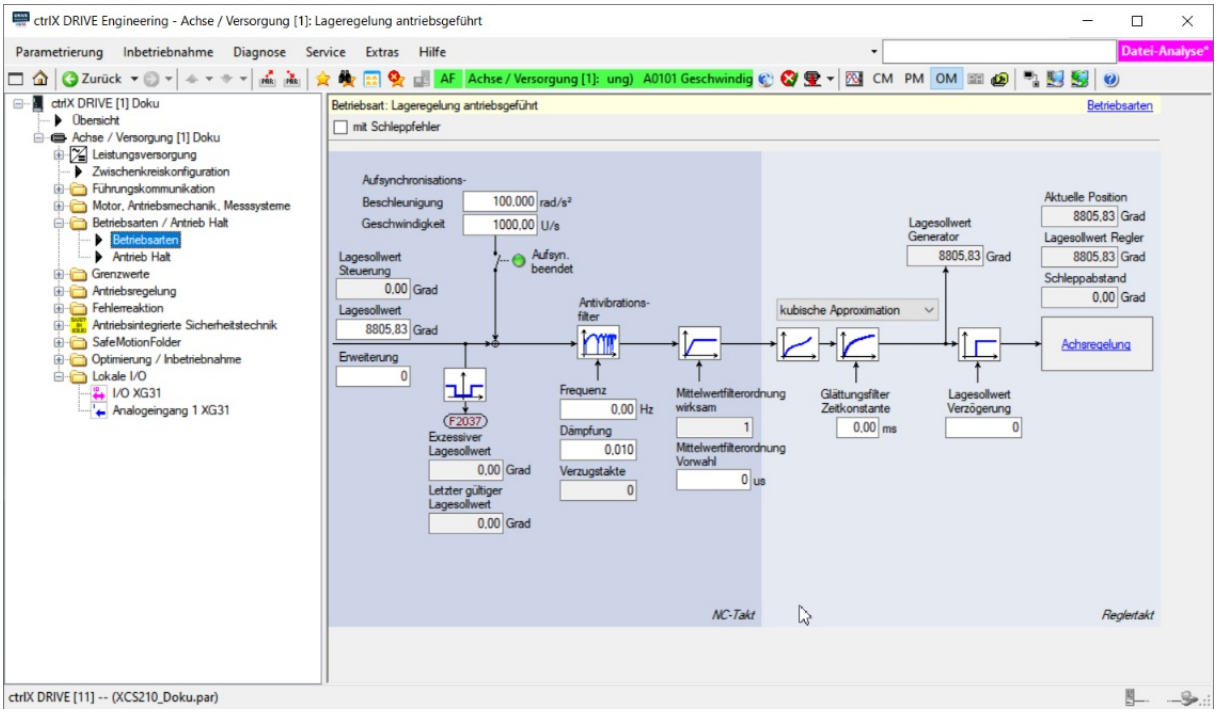

Fig. 255: Position control mode

The following items are configured in the dialog:

- Active actual position value (encoder 1, encoder 2 or hybrid actual position value)
- With or without lag error
- Position command value filter
- Fine interpolation of position command values control
- Synchronization data in the case of drive-controlled position control
- Torque/force feedforward (firmware function "external acceleration feedforward" to be enabled)

The "S-0-0047, Position command value" cyclically transmitted/written by the control unit is displayed in parameter "P-0-0047, Position command value of control". When reading S-0-0047 (e.g., oscilloscope or drive telegram), the drive provides "P-0-0434, Position command value of controller", that takes effect directly at the position controller input. See also Fig. 256

.Additional information and details

- NC-controlled or drive-controlled position control with internal, dynamic synchronization when changing operation modes
- Time base for cyclic command value input defined by "S-0-0001, NC cycle time (TNcyc)"
- Position control to the command value preset in parameter "S-0-0047, Position command value"

- Command value preprocessing in NC cycle
  - Position command value difference monitored with regard to max. velocity (S-0-0091, S-0-0038, S-0-0039, S-0-0113, P-0-0113, motor control frequencies higher than 599 Hz require export licensing, see "Limiting the motor control frequency" in chapter "Motor control frequency")
  - Position command values of the control unit smoothed by means of adjustable average value filter; can be set via "P-0-0041, Position command average value filter time constant; displayed in parameter "P-0-0042, Current position command average value filter order"; maximum of 64 cycles.
  - Anti-vibration filter to prevent vibrations; adjustable via "P-0-0642, AV filter frequency" and “P-0-0643, AV filter damping"; display in “P-0-0644, AV filter delay cycles"
- Fine interpolation of position command value of the control unit to position controller clock; can be switched by means of "P-0-0187, Position command processing mode"
- Adjustable position command value delay in position clocks (P-0-0456, Position command value delay), maximum of 64 clocks.
- Position command value extension (P-0-0100)
- Cyclic acceptance of an additive torque/force command value of the control unit (external acceleration feedforward)
- Quadrant error correction calculation
- Additive position command value taken into account (P-0-0059)
- Command values for velocity and acceleration generated from position command value
- Position command values smoothed via PT1 filter (P-0-0099)
- Master communication command values monitored for failure
- Position control with regard to actual position value encoder 1 (motor or actuator encoder) or actual position value encoder 2 [external (load-side) encoder] or hybrid actual position value can be switched during operation
  The "hybrid actual position value" can be activated via the Productivity Package.
- The external acceleration feedforward function is integrated in the operation mode.
- Velocity feedforward through adjustable factor of 0...120 % (default = 100 %)

The condition for this operation mode is clock-synchronized communication between the control unit and the drive, as it is the case with Sercos interface, for example.

The figure below illustrates the command value preprocessing in the "position control" mode as a block diagram and the downstream position controller

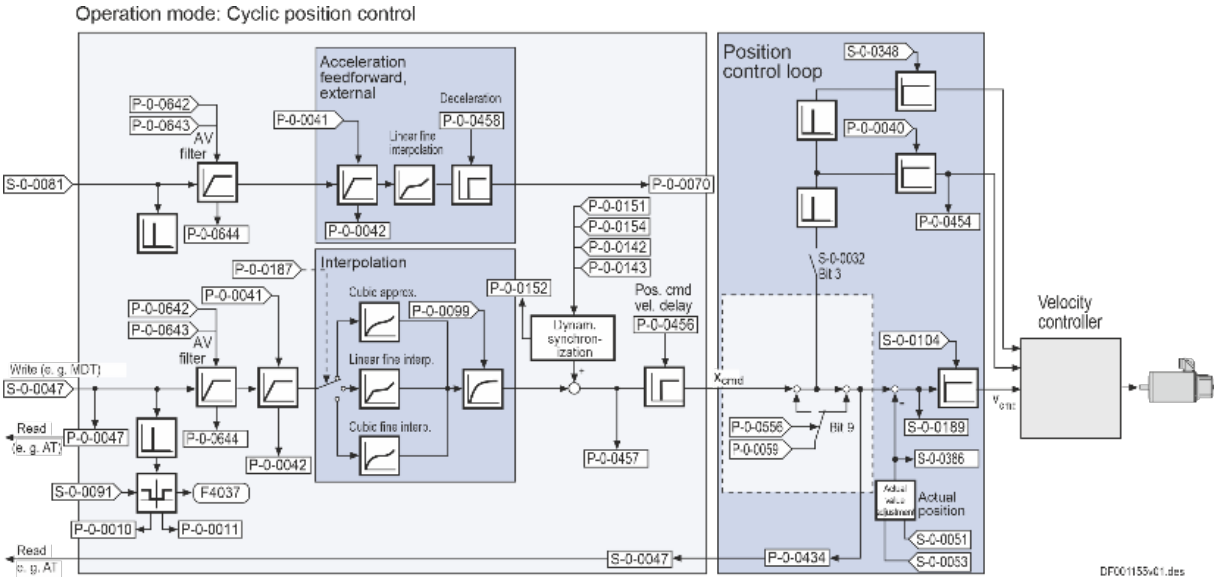

Fig. 256: Command value preprocessing and position control loop in position control mode

See also "Position controller" in section "Axis control/position controller"

See also "Velocity controller" in section "Axis control/velocity controller"

See also "Current controller" in section "Torque/force control"

There are different forms of the "position control" mode which result in the corresponding diagnostic messages when the operation mode was activated (see ↘ “Diagnostics involved” below).

We distinguish the following variants of the mode "position control with cyclic command value input":

- **NC-controlled position control** (cf. A0165, A0102 to A0105)
  The drive generally follows the position command values cyclically input by the master in the NC cycle.
- **Drive-controlled position control** (cf. A0160, A0154 to A0157)
  In the case of a change of operation mode to cyclic position control, the drive provides for the corresponding synchronization process, i.e. it generates, internally by means of the internal synchronization parameters (P-0-0142, P-0-0143, P-0-0154, P-0-0151), a smooth transition of the internal position command value from the current actual position to the new command value characteristic input by the NC. After the synchronization process (P-0-0152, bit 0=1) has been completed, the drive follows the position command values input by the master in the NC clock.
  The "S-0-0047, Position command value" cyclically transmitted/written by the control unit is displayed in parameter "P-0-0047, Position command value of control".
  When the operation mode is activated, the parameter P-0-0047 is once set to the position command value of the drive. With the NC-controlled function, this allows a too big control command value deviation to be detected.
  When **reading** S-0-0047 (e.g., oscilloscope or drive telegram), the drive provides "P-0-0434, Position command value of controller", that takes effect directly at the position controller input.
  See also Fig. 256

  - Dynamic synchronization
    During drive-controlled change of operation mode, the drive makes sure internally that when the operation mode is changed, the transition is carried out in a synchronized way, even if the command value changes abruptly.
    Parameters used:
    P-0-0047, Position command value of control
    P-0-0142, Synchronization acceleration

P-0-0143, Synchronization velocity
P-0-0152, Synchronization completed
P-0-0154, Synchronization direction
P-0-0434, Position command value controller
For modulo axes, observe the following aspects (see also ↘ “Modulo processing”):

The position command value (S-0-0047) is transmitted in the position standardization of master communication (MastCom). If the control has a higher resolution in its internal position command value, additional position information can be transmitted in "P-0-0100, Position command value extension This value is the position remainder standardized with 2^{15} that is ignored for master communication standardization.

The "position command value extension" causes the resolution of the velocity command value and the acceleration command value in the position controller to be increased, and thereby improves the performance of feedforward and quadrant error correction.

The position command values preset by the control can be filtered with an anti-vibration filter to prevent vibrations. For this purpose, the measured or calculated vibration frequency has to be entered in the parameter "P-0-0642, Anti-vibration filter frequency", and the related damping in the parameter "P-0-0643, Anti-vibration filter damping". The resulting delay clocks are displayed in "P-0-0644, Anti-vibration filter delay clocks". For example, the vibration frequency can be determined by measuring "S-0-0189, Lag" and "S-0-0084, Actual torque/force value".

For information on the operating principle of the filter, see "P-0-0642, Anti-vibration filter frequency".

After the anti-vibration filter, the command values can also be smoothed via an average value filter that can be set (Parameter "P-0-0041, Position command average value filter time constant", moving average filter for a maximum of 64 values). The resulting filter degree is displayed via "P-0-0042, Current position command average value filter order". This filter can be used for jerk limitation and thus for prevention of vibrations.

In case of a drive-controlled position control, a jump of the position command value is traveled by a change of the position command average value filter with synchronization motion in control.

For information on the operating principle of the filter, see P-0-0042, Current position command average value filter order"

In addition, a PT1 filter for command value filtering is available with "P-0-0099, Position command smoothing time constant".

The position command value cyclically transmitted in the NC cycle time by the control is fine interpolated in the drive.

Via "P-0-0187, Position command processing mode", it is possible to switch between:

- linear fine interpolator,
- cubic approximator (default setting), or
- cubic fine interpolator (according to contour)

The position command value can be delayed by a maximum of 64 position clocks after the fine interpolator, before it is transmitted to the position controller. Thus, synchronous control of a master axis with the controlled slave axis is possible. The number of position clocks is set using the position command value delay (P-0-0456). The position command value generator without delay (P-0-0457) is entered in a ring buffer and then the position command value with delay is applied to the position command value of controller (P-0-0434).

In the external acceleration feedforward, "S-0-0081, Additive torque/force command value" takes effect in time-synchronized form with the position command value in control (S-0-0047). For this purpose, "S-0-0081 Additive torque/force command value" is delayed with regard to the position command value and output in "P-0-0070, Effective add. torque/force command value" . The delays by the anti-vibration filter, the average value filter, the fine interpolation and the command value delay are emulated. It is not allowed to use the PT1 filter (P-0-0099) with this function.

The firmware function "External acceleration feedforward" has to be activated with the Productivity Package. Otherwise, S-0-0081 is directly applied to P-0-0070 and takes effect immediately.

Before the position controller, the value of the parameter "P-0-0059, Additive position command value, controller", is added to the position command value controller. The axis controller configuration (P-0-0556, bit 9) specifies whether this has an effect on the feedforward, i.e. whether the value is used for calculating the target velocity/target acceleration.

P-0-0556, bit 9 = 0: Additive position command value has no effect on feedforward

P-0-0556, bit 9 = 1: Additive position command value has an effect on feedforward

In the "position control with cyclic command value input" mode, new position command values are transmitted to the drive in every NC cycle. If the command value fails, the position command value is extrapolated.

With active "position control" mode, the calculated velocity required for reaching the preset position command value (S-0-0047) is compared to the maximum velocity ("S-0-0091, Bipolar velocity limit value", "S-0-0038, Positive velocity limit value", "S-0-0039, Negative velocity limit value", S-0-0113, P-0-0113, motor control frequencies higher than 599 Hz require export licensing, see "Limiting the motor control frequency" in chapter "Motor control frequency"). The NC cycle time (TNcyc in S-0-0001) is used as the time base for converting the position command value differences into a velocity.

If the target velocity corresponding to the preset position command value exceeds the value of the maximum velocity, the error message "F4037 Excessive position command difference" is generated.

Via "P-0-0187, Position command processing mode, bit 15, the triggering of the monitoring function can also be parameterized as the warning "E4037 Excessive position command difference warning".

In addition, the two involved command values are written to the following parameters:

- P-0-0010, Excessive position command value
- P-0-0011, Last valid position command value

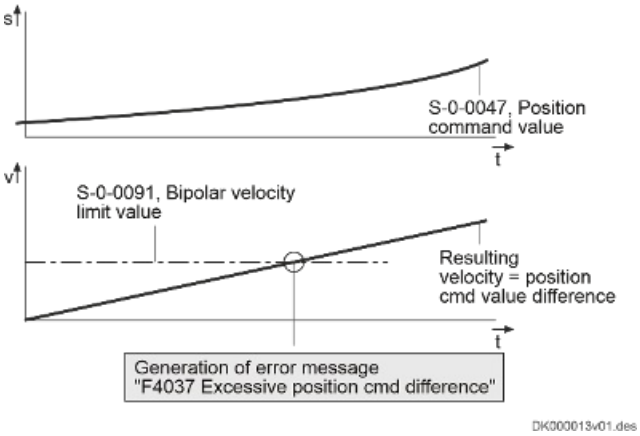

Fig. 257: Monitoring for Error "F4037 Excessive position command difference"

The value entered in parameter "S-0-0091, Bipolar velocity limit value" should be approximately 5 to 10% above the intended maximum velocity of the axis.

If a position control mode has been activated in the drive, the position control loop is monitored. For this purpose, an

"actual position value for the model" is calculated and compared with the real actual position value.

If the monitoring window (S-0-0159) is exceeded, the error "F2028, Excessive deviation" will be generated.

The model monitoring can be deactivated by entering the value "0" in "S-0-0159, Monitoring window of following distance".

See also "Position controller (with corresponding feedforward functions and actual value preprocessing)"

.Parameters and diagnostics involved

.Parameters involved

- S-0-0001, NC cycle time (TNcyc)
- S-0-0038, Positive velocity limit value
- S-0-0039, Negative velocity limit value
- S-0-0047, Position command value
- S-0-0081, Additive torque/force command value
- S-0-0084, Actual torque/force value
- S-0-0091, Bipolar velocity limit value
- S-0-0159, Monitoring window of following distance
- S-0-0393, Command value mode
- S-0-0520, Axis control word
- P-0-0010, Excessive position command value
- P-0-0011, Last valid position command value
- P-0-0041, Position command average value filter time constant
- P-0-0042, Current position command average filter order
- P-0-0047, Position command value of control
- P-0-0059, Additive position command value, controller
- P-0-0070, Effective additive torque/force command value
- P-0-0098, Max. model deviation
- P-0-0099, Position command smoothing time constant
- P-0-0100, Position command value extension
- P-0-0142, Synchronization acceleration
- P-0-0143, Synchronization velocity
- P-0-0151, Synchronization window for modulo format
- P-0-0152, Synchronization completed
- P-0-0154, Synchronization direction
- P-0-0187, Position command processing mode
- P-0-0434, Position command value controller
- P-0-0456, Position command value delay
- P-0-0457, Position command value generator
- P-0-0458, Delay of add. command values
- P-0-0556, Config word of axis controller
- P-0-0642, Anti-vibration filter frequency
- P-0-0643, Anti-vibration filter damping
- P-0-0644, Anti-vibration filter delay clocks

.Diagnostics involved

- A0102 Position control, encoder 1
- A0103 Position control, encoder 2

- A0104 Position mode lagless, encoder 1
- A0105 Position mode lagless, encoder 2
- A0154 Position mode drive-controlled, encoder 1
- A0155 Position mode drive-controlled, encoder 2
- A0156 Position mode drive-controlled lagless, encoder 1
- A0157 Position mode drive-controlled lagless, encoder 2
- A0160 Position control drive-controlled with axis control word
- A0165 Position control with axis control word
- E4037 Excessive position command difference warning
- F4037 Excessive position command difference