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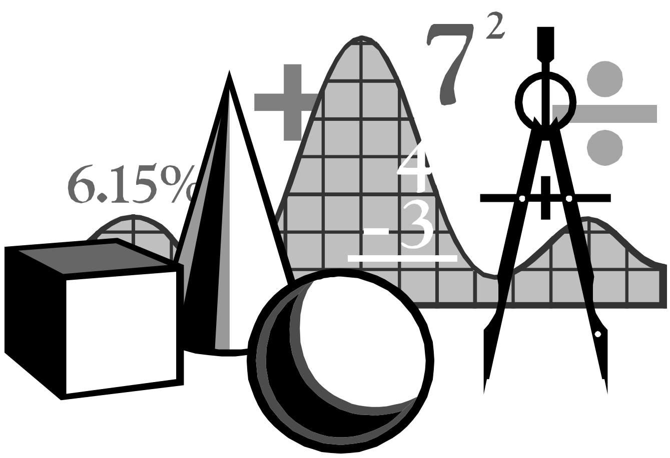
UD7000

Application
"Closed-Loop Process Control"

with U/f, FO, EC and SLV



As per: 05.08.03

Application
"Closed-Loop Process Control"

Upwards of software version A18.07

Application

Application "closed-loop process control" is used wherever any process variables (pressures, temperatures, speeds, forces, flow rates, mixing ratios and filling levels etc.) must be maintained constant.

The only precondition is a corresponding measured value transducer which converts the relevant variables to an analogue signal or a frequency. Sensors with "rising" or "falling" characteristic may be used.

Figure 1 shows, by way of example, a closed-loop web speed control system. Owing to the variable winding diameter, the web speed would change at constant motor speed. This error is compensated for by feedback of the actual speed value.

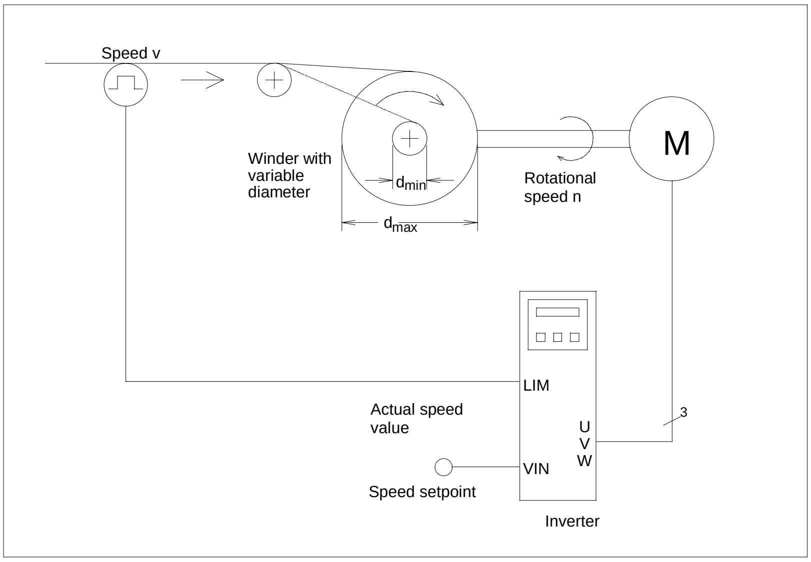


Figure 1: Example closed-loop speed control

Principle of closed-loop process control

1st configuration (setpoint at VIN, actual value at LIM, both unipolar)

A setpoint (analogue 0..10 V) is preset via the input terminal VIN. This setpoint is smoothed with a time constant (parameter 3C) and scaled via a P-element (parameter 41).

A setpoint (analogue 0..10 V or digital 0..100 kHz) is preset via the input terminal LIM. This setpoint is smoothed with a time constant (Parameter 3D) and scaled via a P-element (parameter 36 resp. 42).

Parameter DA generates an offset.

These three variables are added (summing point) and applied to a PI-element. Gain and time constant of the PI-element can be varied via parameters DC and DB. The output variable of the PI-element is limited to the maximum frequency of the inverter. The limitation acts in unipolar manner (2-quadrant: 0 Hz... +f_{Max}).

The controller can be bypassed via an open-loop control input in order, for instance, to allow start-up operations. In such a case, only the offset and the setpoint are active, and the sum of these two variables is then applied directly to the setpoint of the actuator.

If the actual value is incorporated as an absolute value (e.g. single-track pulse encoder), both directions of rotation can be selected via the Drive Enable FWD/REV.

Any drive technology may be used as the "actuator":

U/f actuator
EC (rotational speed or torque-controlled)
FO (rotational speed or torque-controlled)
SLV (rotational speed or torque-controlled)

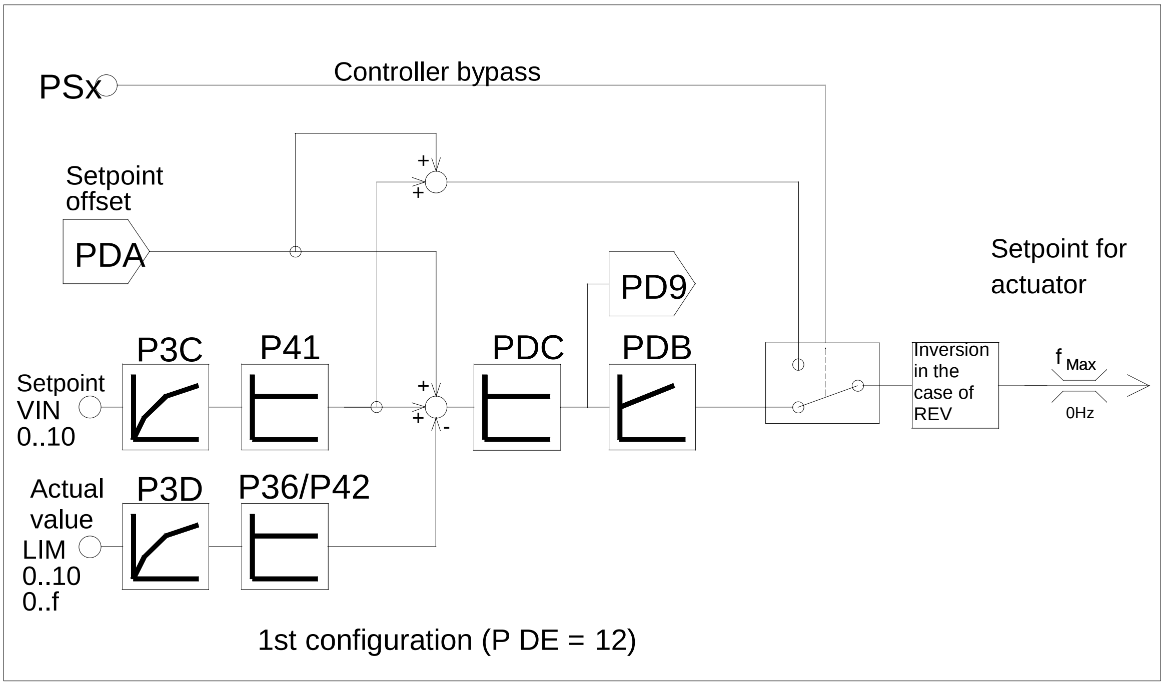


Figure 3: Controller structure for 1st configuration.

The Drive Enable can be issued both via FWD and via REV.

2nd Configuration (unipolar setpoint at LIM, any actual value at VIN)

A setpoint (analogue 0..10 V or digital 0..100 kHz) is preset via the input terminal LIM. This setpoint is smoothed with a time constant (parameter 3D) and scaled via a P-element (parameter 36 resp. 42). If the actual value is bipolar, both directions can be selected via the Drive Enable (FWD/REV).

An actual value (analogue 0..10 V or +- 10 V) is preset via the input terminal VIN. This analogue value is smoothed with a time constant (parameter 3C) and scaled via a P-element (parameter 41).

Parameter DA generates an offset.

These three variables are added (summing point) and applied to a PI-element. Gain and time constant of the PI-element can be varied via parameters DC and DB. The actual variable of the PI-element is limited to the maximum frequency of the inverter. The limitation acts either in bipolar manner (4-quadrant: $-f_{Max}$ ... $+f_{Max}$) or in unipolar manner (2-quadrant: 0 Hz... $+f_{Max}$), depending on the selected operating mode.

Any drive technology may be used as the "actuator":

U/f actuator
EC (rotational speed or torque-controlled)
FO (rotational speed of torque-controlled)
SLV (rotational speed or torque-controlled)

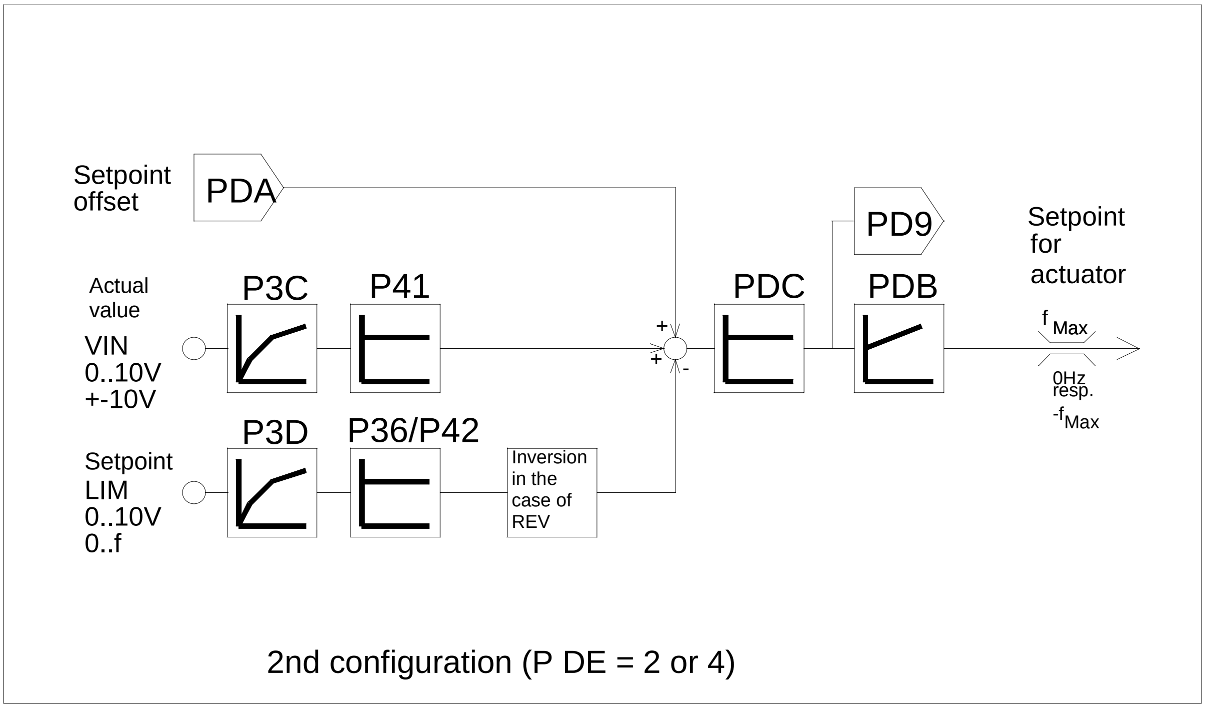


Figure 4: Controller structure, 2nd configuration

Input and output terminals

VIN: Analogue input -10 V....+10 V (typical setpoint)
LIM: Analogue (0..10 V) or pulse (0..100 kHz) input (typically actual value)
FWD: Binary input Drive Enable in forward direction
REV: Binary input Drive Enable in reverse direction
R/J; PSx: Input for bypassing the controller

Parameters

P 23: Maximum frequency
P 2C: Application 600, 610, 611, 620, 621, 650, 651: Closed-loop process control with U/f actuator, EC, FO, SLV in speed or torque control
P 31: VIN input +- 10 V
P 32: LIM input 0..10 V resp. binary pulses
P 3C: Smoothing time constant for VIN input
P 3D: Smoothing time constant for LIM input
P 36: Scaling LIM, if this operates as pulse input
P 41: Scaling VIN
P 42: Scaling LIM, if this operates as analogue input
P D8: Indication, manipulated variable
P D9: Indication, control error * P-gain
P DA: Setpoint offset
P DB: Integral-action time
P DC: P-gain
P DE: Configuration, 2 or 4-quadrant

Commissioning

1. Place the motor into operation as U/f, EC, FO or SLV (parameter reset, select application, mains on-off; enter motor data, test run, etc.), then set test mode to 0.
2. Select closed-loop process control application 600..651, mains off-on.
3. Select parameter 23 - maximum frequency approx. 10% higher than the maximum motor rotational frequency occurring in order to always have adequate control reserve.
4. Select the configuration corresponding to the description. The following are permitted:
   DE = 2 (2nd configuration and 2-quadrant)
   DE = 4 (2nd configuration and 4-quadrant)
   DE = 12 (1st configuration and 2-quadrant)
5. Parameter DA - Setpoint offset = 0
   Parameter DB - Integral-action time = 1000
   Parameter DC – P-gain = 256
6. Scale the VIN input
   Set parameter 41 - fixed frequency 1 corresponding to the maximum voltage of the VIN input and the maximum output frequency
   e.g.:
   $U_{VIN,Max}$ = 6 V, $f_{Motor,max}$ = 50 Hz: => P41 = 50 Hz * 20 V / 6 V = 166.7 Hz.
   Check (LIM input jumpered with COM):
   -10 V at VIN: Parameter D9 - Control error indicates 0
   +10 V at VIN: Parameter D9 - Control error indicates 10*P41 (e.g. 166.7*10 = 1667)
7. Configure the LIM input:
   Either digital pulses:

Parameter 32 - Function LIM input = 3
Set parameter 36 - Pulse count LIM input corresponding to the max. LIM frequency occurring and the max. output frequency (it may be necessary to round it).
e.g.: $f_{LIM,max}$ = 800 Hz, $f_{Motor,max}$ = 50 Hz: => P36 = 800 Hz/50 Hz = 16.
Check: (VIN input jumpered with COM)
0 V at LIM: Parameter D9 - control error indicates 0
$f_{Motor,max}$ at LIM: Parameter D9 - control error indicates -10* $f_{Motor,max}$ (e.g. -10*50 = -500)

or analogue signal 0..10 V:
Parameter 32 - Function LIM input = 0
Set parameter 42 - fixed frequency 2 corresponding to the maximum voltage excursion at the LIM input and the maximum output frequency
e.g. $U_{LIM,Max}$ = 7 V , $f_{Motor,max}$ = 50 Hz: => P42 = 50 Hz * 10 V / 7 V = 71.4 Hz
Check: (VIN input jumpered with COM)
0 V at LIM: Parameter D9 - control error indicates 0
+10 V at LIM: Parameter D9 - control error indicates -10*P42 (e.g. -10*71.4 = -714)

8. Scale the setpoint offset. In order to do this:
   Apply 0 V/0 Hz to VIN and LIM
   Parameter D9 - read off control error and enter the value with *inverted* sign in parameter DA - setpoint offset. This adjusts the control error to zero.

9. Determine the control direction:
   Configuration 1:
   If the actual value (LIM) increases (decreases) with increasing setpoint (VIN), the control direction is "positive"("negative").

   Configuration 1:
   If the actual value (VIN) increases (decreases) with increasing setpoint (LIM), the control direction is "negative" ("positive").

   After the sign of the control direction has been determined, always follow the steps below.

10. Optimise the PI-controller:
    Increasing parameter DB - integral-action time decreases the I component.
    Increasing parameter DC – P-gain boosts the P-component.
    The smoothing time constant of inputs VIN and LIM can be adapted with parameters 3C and 3D.