Pumps and Pump Systems | Lenze VFDs

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1 Introduction

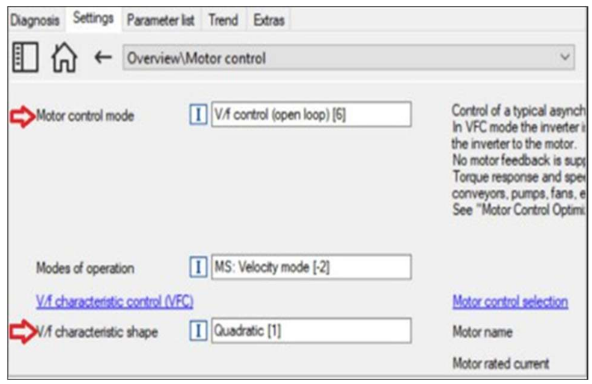
This guide is intended for engineers and installers applying the i550 in pumping applications. Unlike the generic i550 manuals this guide purely focuses on pump specific functionalities. For additional features like mapping of various fieldbuses please refer to the Lenze Product pages or the Help Texts of the Lenze VFD PC-Tool Drive Starter.

2 General Settings for Pumps

Motor Control Mode:

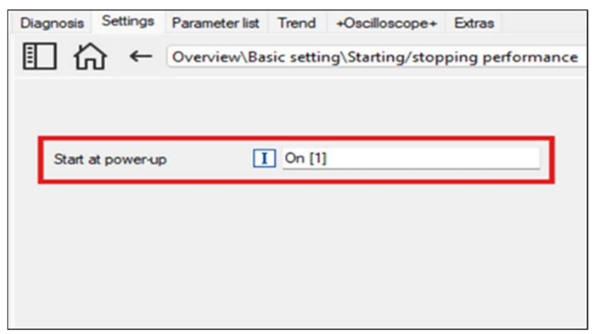
For simple and energy efficient motor control Lenze recommends the following motor control settings:

AC Induction motors, set the “Motor control mode” (P300.000) = “V/f control (open loop) [6]” and set “V/f characteristic shape” (P302.000) = “Quadratic [1]”. For fans with PMAC motors, “Motor control mode (P300:000)” should be set to “Sensorless Contr. (SLSM-PSM) [8].”



Start on Power Up

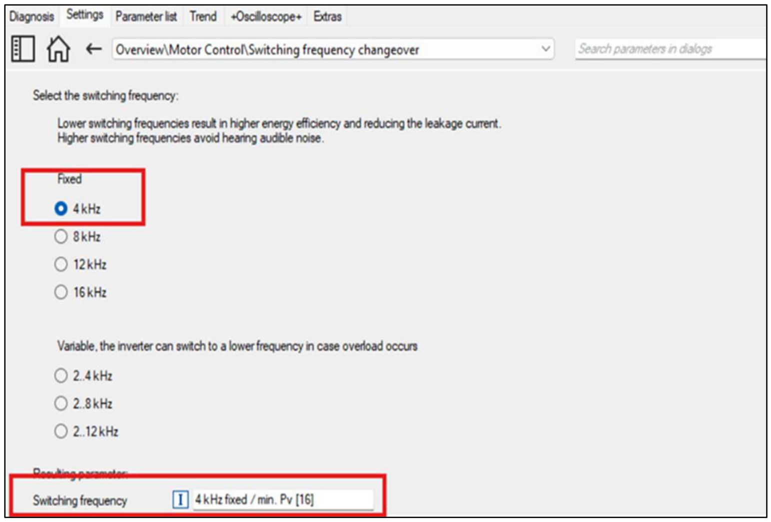
A common requirement for drives in fan applications is to start on the application of power if the RUN command is already asserted. Normally, the drive must power-up first and then receive a RUN command to avoid a FAULT. The drive may be programmed to allow start on power-up simply by setting “Start at Power-up” (0x2838:002 – P203:002) = [1] On



Light Duty Mode

The light duty mode is in general available on i5x0 cabinet ≥ 3 kW, IP21/31 (NEMA 1) inverters but not for IP66 & IP55 inverters. The standard default setting is heavy duty but can be parameterized also for light duty, allowing a continuous higher current rating with the same inverter. This helps the customer to select a smaller inverter.

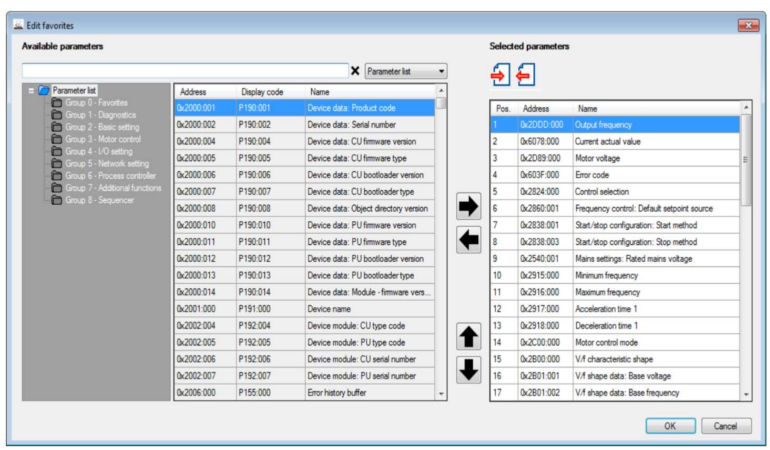
To use light duty mode the drive must use 4kHz carrier frequency (0x2939:000- P305:000 Switching frequency).



Once done activate light duty mode: Set "Inverter load characteristic: Duty selection" (0x2D43:001 – P306:001) = Light Duty [1].

End-User Experience Optimization (Favorite menu)

Select within Easy-Starter the top 5-10 parameters in preferred order in the favorite menu.

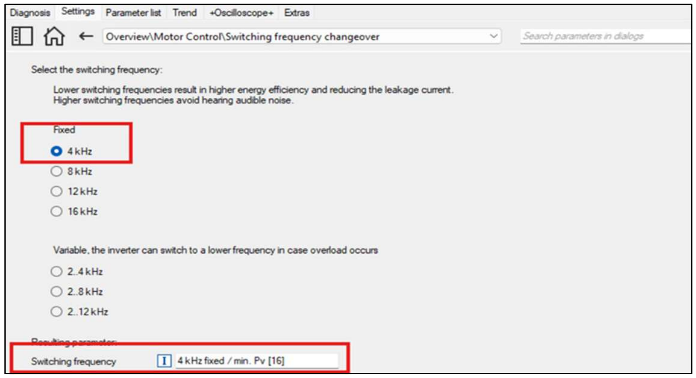


Leakage current optimization

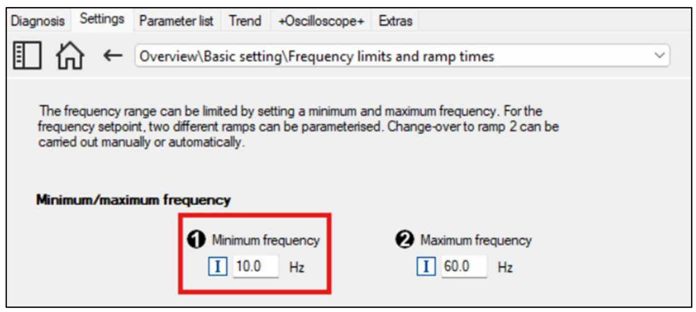
The i500 inverters do in general have low leakage currents. In principle the i5x0 inverters can be used up to 11 kW on a 30mA RCD device, details can be found in the respective product documentation. Usage of short motor cables and removing the IT-screws (available on i5x0 cabinet inverters) can further decrease the leak-age current.

Also, the following settings can help to minimize the leakage current:

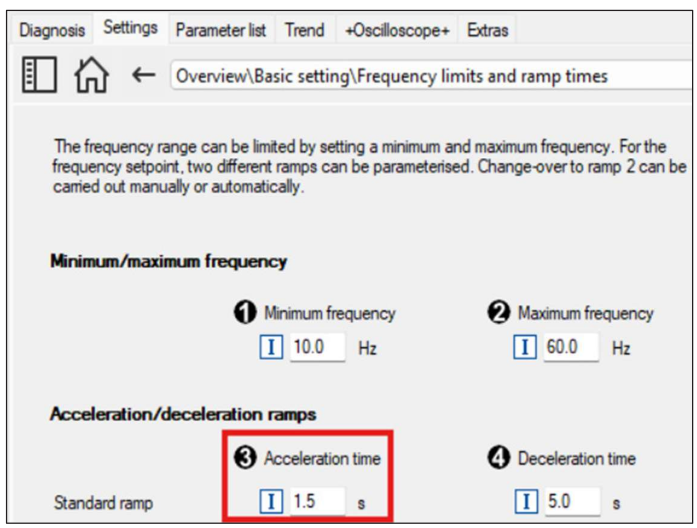
1. Set "Switching frequency" (0x2939:000- P305:000) for the lowest possible set frequency.



2. Set the minimum frequency to 15 to 20 Hz. This means the motor runs at no less than that speed on start-up. "Minimum frequency" (0x2915:000 – P210:000)



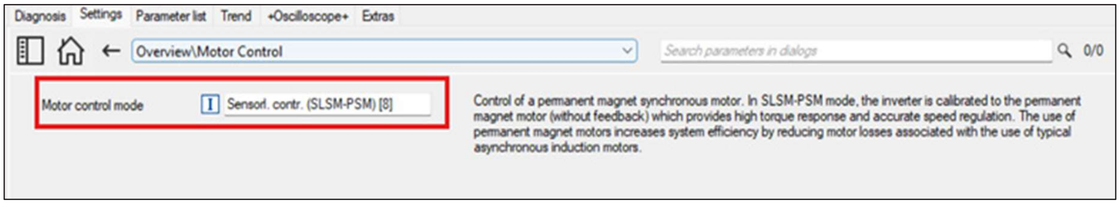
3. Set the fastest acceleration time possible. This action reduces the chance of tripping during speed increase. "Acceleration time 1"(0x2917:000 – P220:000).



4. Use the shortest possible motor power cables. Long leads add capacitance to the system and increase the leakage level.
5. Make sure there is a good ground connection. The motor power cables should have a shield and be terminated on the drive end.
6. Check the motor manufacturer for grounding requirements on their side.

3 PM Motor Control Support

Lenze offers a very powerful and flexible PM motor control scheme “SLSM-PSM”. Parameter 0x2C00:000-P300:000 [Motor control mode] with selection [8] SLSM-PSM. This selection works best at carrier frequencies of 8kHz.



Most important is to select the right Low speed method: 0x2C13:000 with the two options:

[2] = i/f based

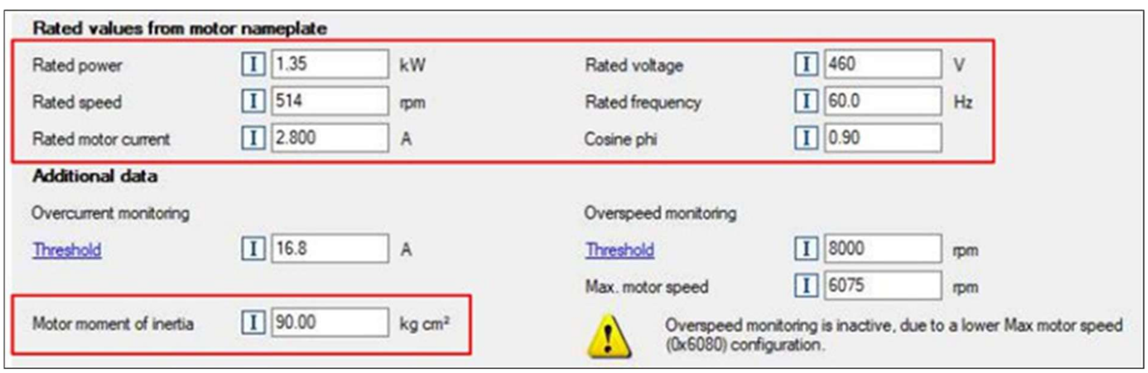
i/f based is the recommended universal method for any motor in particular for pump & fan applications and typically applied in the market as it is easy to commission with OK performance.

[1] -Carrier Based [DEFAULT Setting]

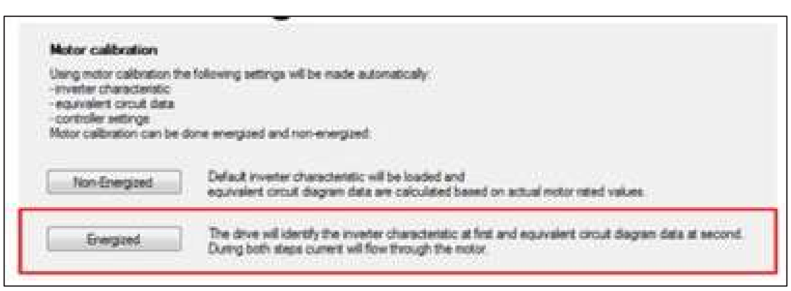
This is the Lenze unique method to support dynamic and precise motor control even in low speed with a possible stating torque of up to 200%. It is particularly easy to use and powerful with the Lenze IE5 motors. It is recommended for dynamic applications; however, it might not be suitable for every motor.

Basic Commissioning Steps

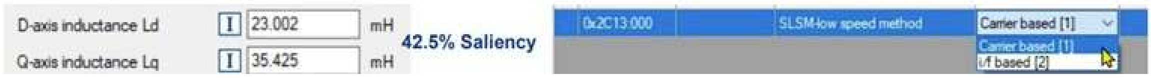
1. Enter motor nameplate data



2. Perform Energized Calibration

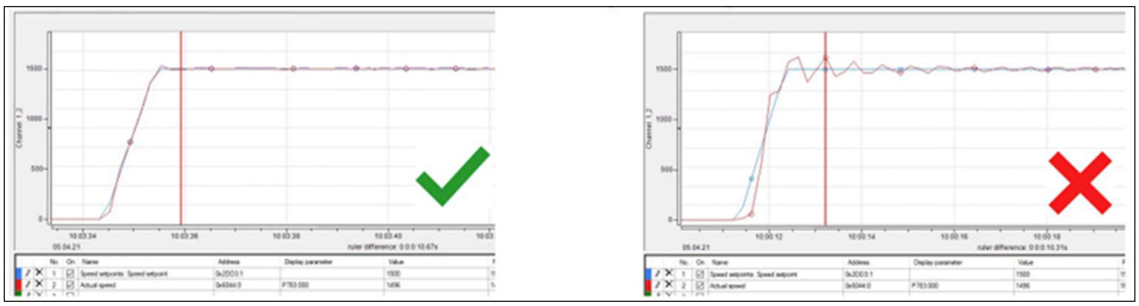


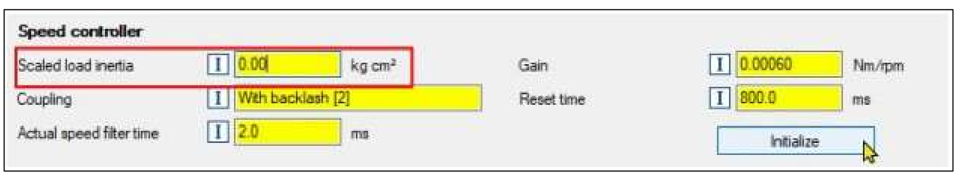
3. Check the Ld and Lq inductance values and determine the saliency. If saliency is less than 5...10% then set “SLSM-low speed method” (0x2C13:000) to i/f based [2]; otherwise, leave Carrier Based [1] selected



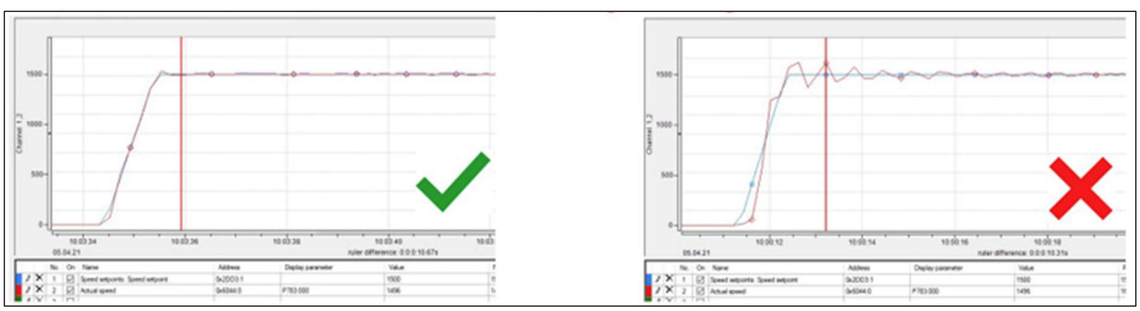
4. Configure a trend or trace plotting “Speed setpoint” (0x2DD#:001) versus “Actual speed” (0x6044:000-P783:000). Attempt to run the motor up to rated / application speed.

   If the motor does not start or is not able to get to set speed, you may need to tune the low-speed range, please refer to “**low speed [non-observable] range tuning advice**” at the end of this procedure.



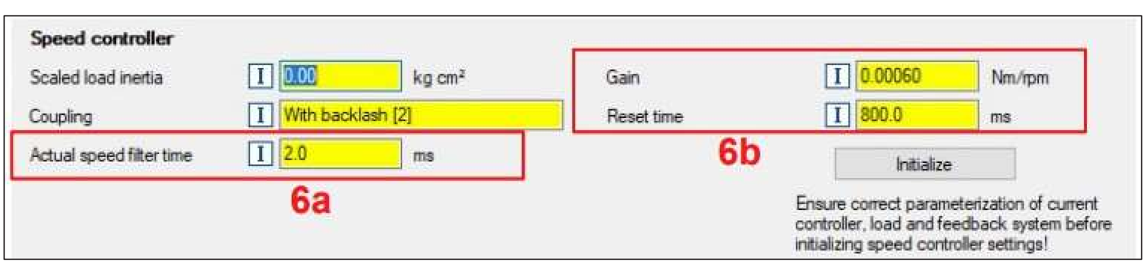


If actual speed is still not tracking setpoint satisfactorily for the application, check the trend again. Begin manual speed loop tuning as described in step 6.

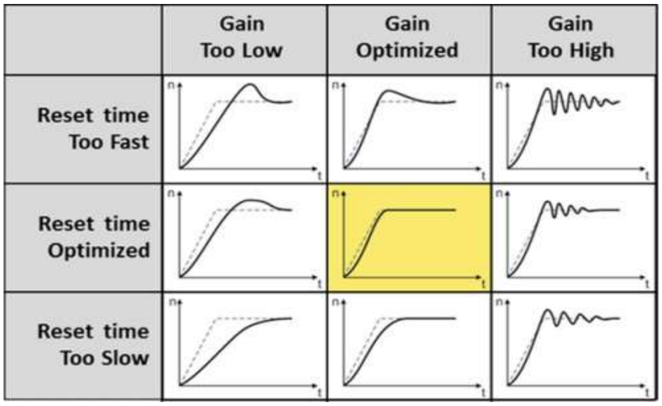


6. Manually tune Speed Controller settings:

a) Increase actual speed filter time [to 4.0...5.0 ms], check the trend to see if actual velocity is tracking setpoint satisfactorily. If the tracking is still not satisfactory, then continue to step 6b.



b) Adjust Speed controller Gain and Reset time using the advice in the graphic below. Generally, adjustments to Gain and Reset time are done in +/- 10...30% increments. After each adjustment, check the trend to see the effects and determine if the actual velocity is tracking setpoint satisfactorily. Once the tracking is satisfactory, you are done.



Low Speed [non-observable] range tuning advices

0x2C13:000 [SLSM Low speed method] = [1] -Carrier Based [DEFAULT Setting]

- If the motor hums but does not start or takes longer than set time to accelerate, then increasing the HF Injection amplitude [0x2C10:001] may be necessary. Increase 0x2C10:001 in 10% increments to get satisfactory starting/acceleration.
- Set the HF injection range to a value lower than the lowest continuous or long-term operating speed for the application, but not lower than necessary for the application. This ensures the long-term/continuous operation will be in the high speed (observable) range.
- Some applications/motors perform better with faster acceleration through the low-speed range. If necessary, apply the 0x291B:000 [Auto-change.thresh.ramp2] for auto switching from accel ramp time 1 to ramp time 2.

“SLSM Low speed method” (0x2C13:000) = [2] - i/f based

- The most common problem with the low-speed range operation, in this mode, is instability and/or stalling when at the transition point from low-speed range to high-speed range. This is typically due to the injected current being higher than necessary. Tuning (typically reducing) the low-speed current values, “Acceleration current” (0x2C12:001) and “Standstill current” (0x2C12:002), is usually necessary, especially for applications with variable or quadratic torque profiles.
- Tuning of “Acceleration current” (0x2C12:001) and “Standstill current” (0x2C12:002) is this mode is a balancing act. Higher current values than necessary will cause instability while transitioning to the high-speed observable range. Lower current values may cause problems starting and driving the application in the low-speed range if high torque is required in that range.
- In this mode a higher transition point is typically beneficial. Reduction of the default [10%] should only be done if absolutely necessary for the application. Increasing to 20...30% can have stability benefits, if that application allows

Increase the base output voltage on the i550 motec

The maximum possible output voltage depends on the DC-Bus voltage. Depending on the amount of capacitors, the voltage ripple may be quite high.
This parameter shall provide a selection on which DC-Bus voltage level the output voltage must be limited.

Value	Meaning	Description
0	Automatic(default)	Output voltage will be limited depending on active control mode
1	Minimum	Output voltage will be limited to the bottom value of DC-Bus voltage
2	Average	Output voltage will be limited to the average value of the DC-Bus voltage

Using the service setting - Limit Output Voltage 0x2DE0:029, the base output voltage on the inverter can be increased by approximately 30.0 V. This increases the base output voltage at the frequency inverter output close to the mains input voltage.

To do this, change the parameter 0x2DE0:029 from "Automatic (0)" to "Average (2)".

4 PID – temperature and pressure control

Proportional Integral Differential (PID) control is a closed-loop method that monitors a process variable, such as pressure or temperature, and requires the fan to vary its speed in order for that variable to be held to a constant value.

Common applications requiring PID control include heating, cooling or pressure.

First, an appropriate analog sensor is installed into the system. This could be a pressure sensor, a thermal sensor or other.

PID applications are either “normal acting” or “reverse acting”. This term is from the perspective of the fan in relation to the monitored process variable. If an increase in the speed of the fan results in an increase in the monitored process variable (such as direct pressure), then the PID application is “normal acting”. If an increase in the speed of the fan results in a decrease in the process variable (such as a fan supplying cooling air to a process monitoring temperature), then the process is “reverse acting”.

Set the operating mode:

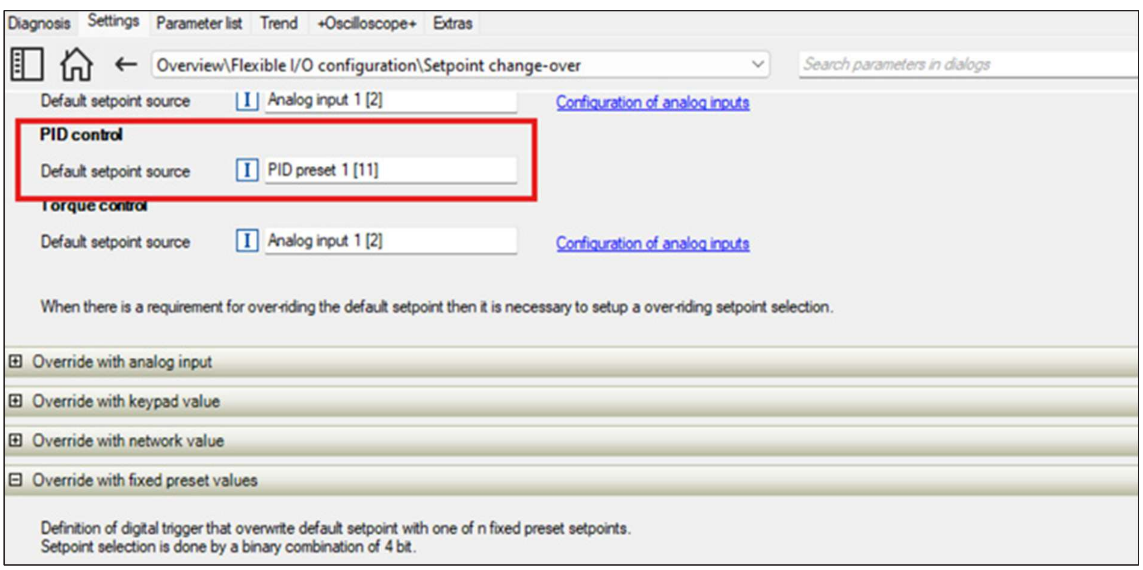
Set the “Operating mode” (0x4020:001 - P600:001) for either “Normal operation [1]” or “Reverse operation [2]” as appropriate for the application.

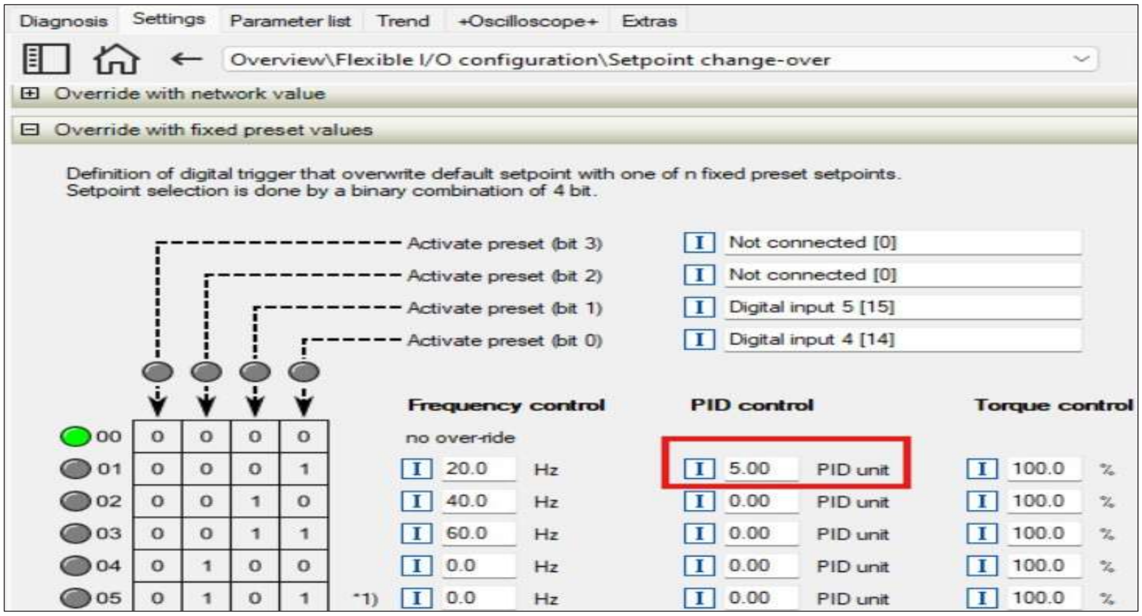
Program the analog input:

Next, we need to program which drive analog input will be used as the monitored process variable. Set “PID process variable” (0x4020:002 - P600:002) either equal to “Analog input 1 [1]” or “Analog input 2[2]”.

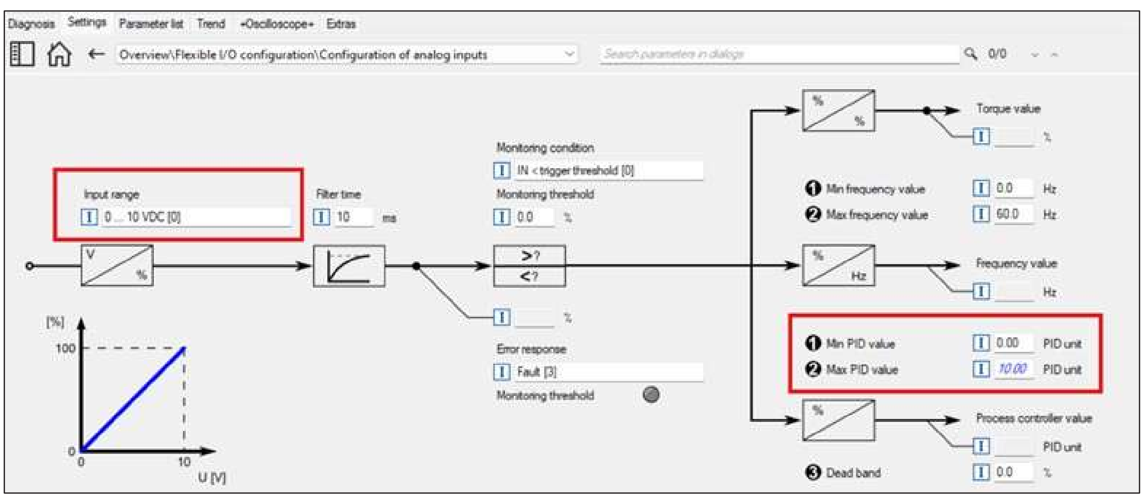
Program the setpoint source

Next, we need to program the drive for where the set point source is. The set point is the command value the drive is trying to get the monitored process variable to match. Set point sources can include the keypad, an analog signal (must not be the same analog input as the monitored process variable) or a predefined internal set point. Set “Default set point source” (0x2860:002 - P201:002)” to one of the following selections as appropriate: “Keypad [1]”, “Analog input 1[2]”, “Analog input 2[3]”, or “PID preset 1 [11]”. If you use “PID preset 1 [11]” as the setpoint, ensure you also program that desired set point value in “Preset 1” (0x4022:001 - P451:001).





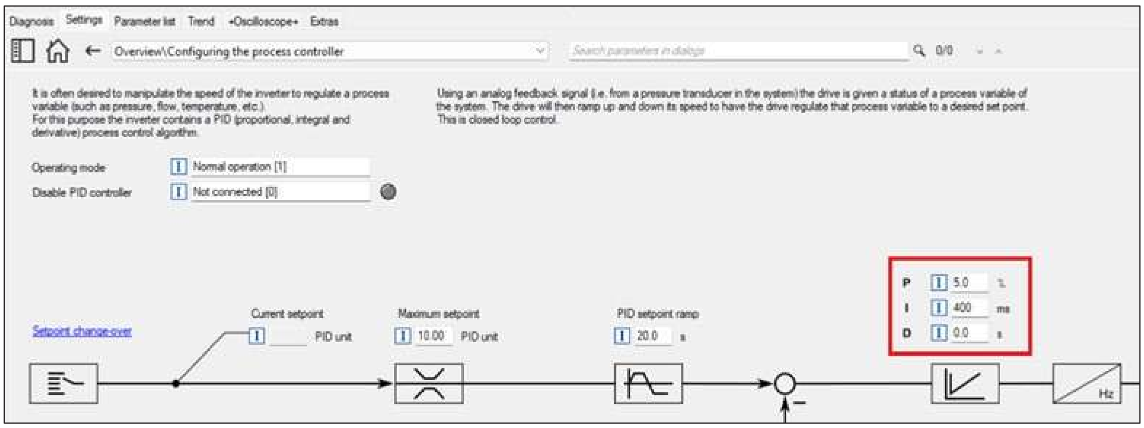
Please note, the set point value is in User defined PID units, which in turn are configured in the monitored process variable's analog input channel configuration. Program both the "Min PID value" (0x263x:004 - P43x:004) and the "Max PID value" (0x263x:005 - P43x:005) to match the signal range of the analog sensor used to monitor the process variable.
Enter this value in PID units (so if the sensor was 0-10VDC = 0-10PSI, set 0x263x:004 - P43x:004 = 0 and 0x2363x:005 - P43x:005 = 10)



PID tuning:
The PID loop must then be tuned on to the running system for the application. A common approach to PID tuning is the following.
1. To deactivate the I-component, set the reset time for the I-component to 6000 ms in "PID I-component" (0x4049:000 - P602:000). With this setting and the default setting of "PID D-component" (0x404A:000 - P603:000), the process controller operates as P controller.
2. Increase gain of the P-component step by step in "PID P-component" (0x4048:000 - P601:000) until the system becomes unstable (oscillates).

3. Reduce the gain again until the system is stable again (stops oscillating).
4. Reduce the gain by another 15%.
5. Set reset time for the I-component in “PID I-component” (0x4049:000 - P602:000). With this setting it should be noted that too low reset time may cause overshoots, especially in case of high steps of the system deviation.
6. Optional: set the gain of the D component in “PID D-component” (0x404A:000 - P603:000).

With this setting it should be noted that the D-component responds very sensitively to electrical noise disturbances on the feedback, as well as digitization errors. For most systems, the “PID D-component” (0x404A:000 - P603:000) may be left at a value of 0. This is typically only required for extremely fast acting systems.



5 Minimum flow rate (Seal life and energy conservation)

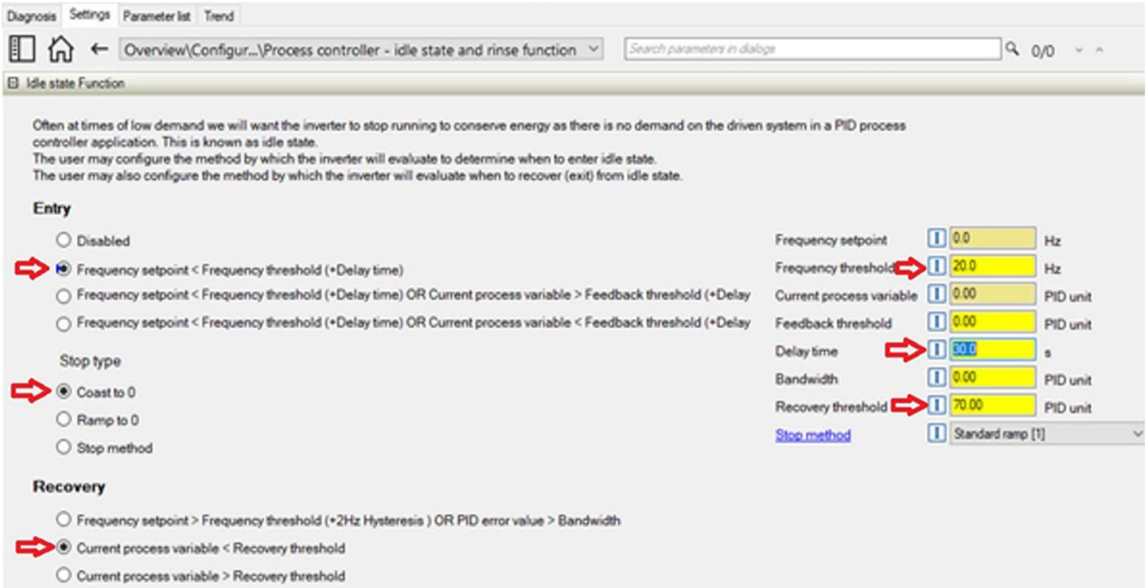
Centrifugal pumps often specify a minimum flow rate be maintained through the pump while running in order to keep the seals from overheating. Similarly, if a minimum flow rate is not maintained it is often desired for the pump to shut off to conserve energy.

If a centrifugal pump is being used in a PID control application the Sleep function may be used for this purpose.

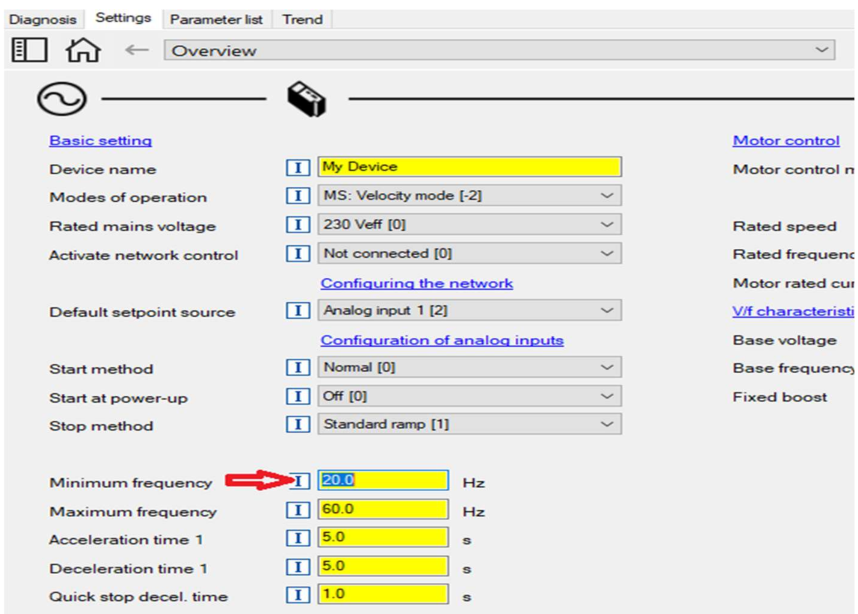
The “PID sleep mode: Activation (P610:001)” should be set to “Output freq.< threshold [1]” for a centrifugal pump application. The “Frequency threshold (P610:003)” must be set for a low value determined for the application to be just below the minimum flow rate being required. A “Delay time (P610:005)” must be entered. A value should be selected that ensures the application should indeed have the pump shut off. If too short a time period is selected, the application may chatter.

A pumping application recovery is typically desired to occur based upon the monitored process. Set the “Recovery P610:006)” to either “PVar<recovery thresh. [1]” for normal acting PID applications or to “PVar>recovery thresh. [2]” for reverse acting PID applications.

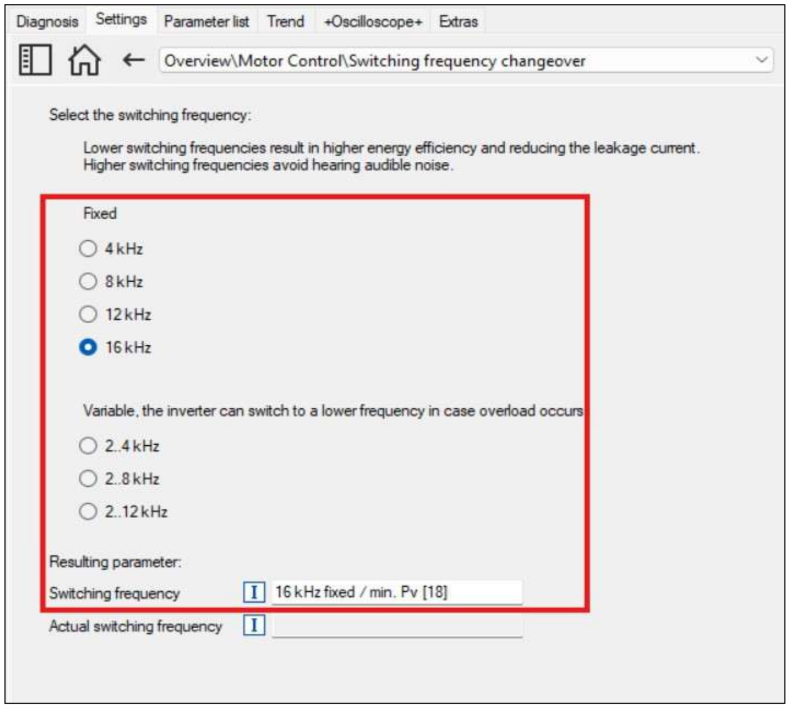
Finally, set the “Recovery Threshold (P610:008)” for the maximum value which the application can tolerate as a variance for the monitored process variable. This value is entered in user defined PID units and is in scale. (i.e., if the process set point was 80 and a max drop to a value of 70 could be tolerated, enter 70).



If a pump is being used in a non-PID application, the drive's "Minimum frequency (P210:000)" setting can be used for this purpose. Enter a value appropriate so that the desired minimum flow rate is expected to be maintained.



6 Carrier frequency selection and audible noise

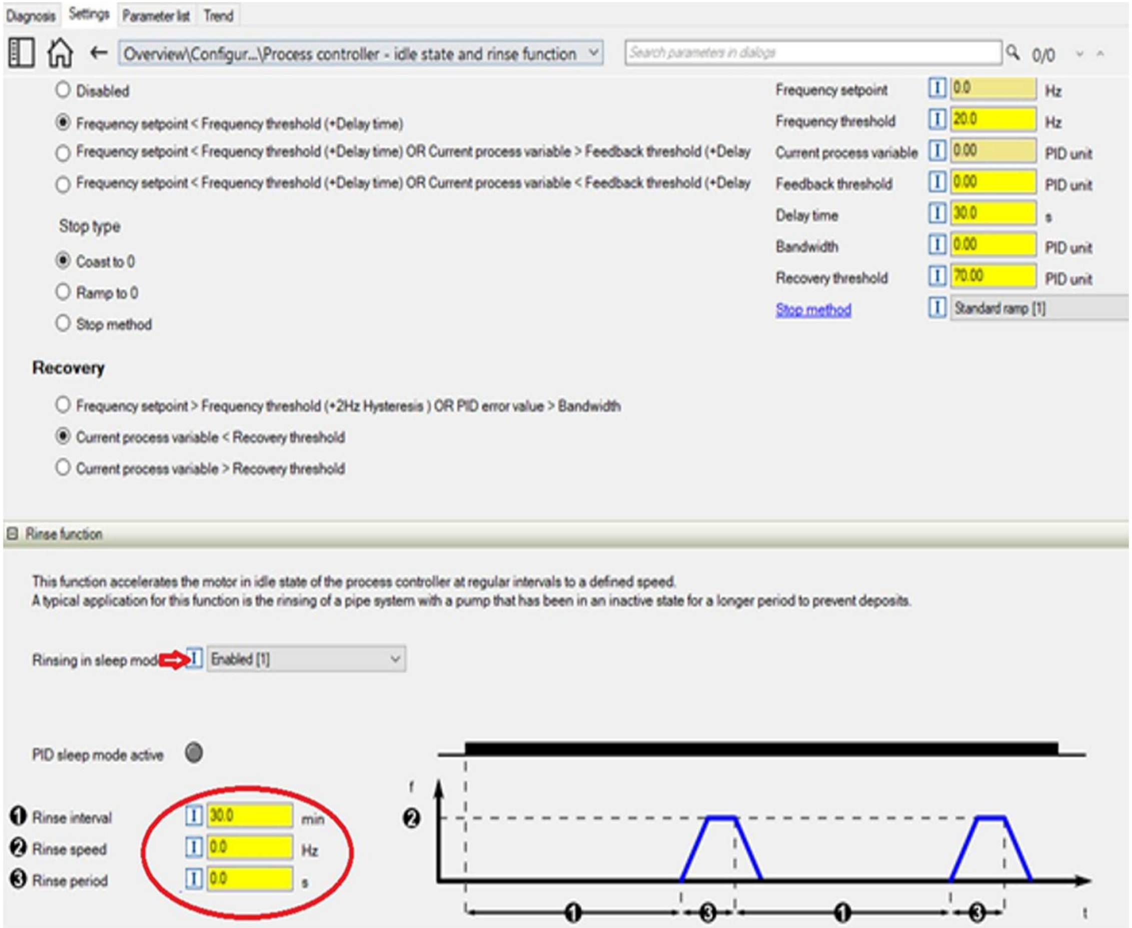


"Switching frequency" (0x2939:000- P305:000) sets the carrier frequency (switching frequency) of the drive's output IGBT's. Higher switching rates result in less audible noise (electric motor whine) emitted from the motor, but the efficiency of the drive decreases as the carrier frequency rises. Therefore, this parameter should be set to the lowest value which yields acceptable sound levels. Most people cannot hear excessive electric motor whine at frequencies of 8kHz; however, some are more susceptible to that audible frequency. I500 series drives allow settings up to 16kHz to elevate the frequency beyond the range of human hearing.
It must be noted that lower carrier frequencies should be used if leakage current is a concern for GFCI or RCD compatibility. It should also be noted that the ability to operate a drive at higher carrier frequencies depends on the drive's horsepower rating, driven load, drive enclosure, and ambient temperature. Consult the derating factors in the drive's Project Planning guide for specific data for your application.

7 Rinse (in PID applications using the sleep function)

Fluids may contain particles in suspension (i.e., drinking water may contain sediment). If a pump is stopped for long enough, these particles may fall out of suspension and build up in the pump. This, in turn, can cause wear for the pump seals and performance problems. To prevent this the i500 features a Rinse function. This periodic function runs the pump at a programmed speed and for a programmed period of time to churn back up the fluid in the pump to keep the particles in suspension within the fluid while the drive is in Sleep.

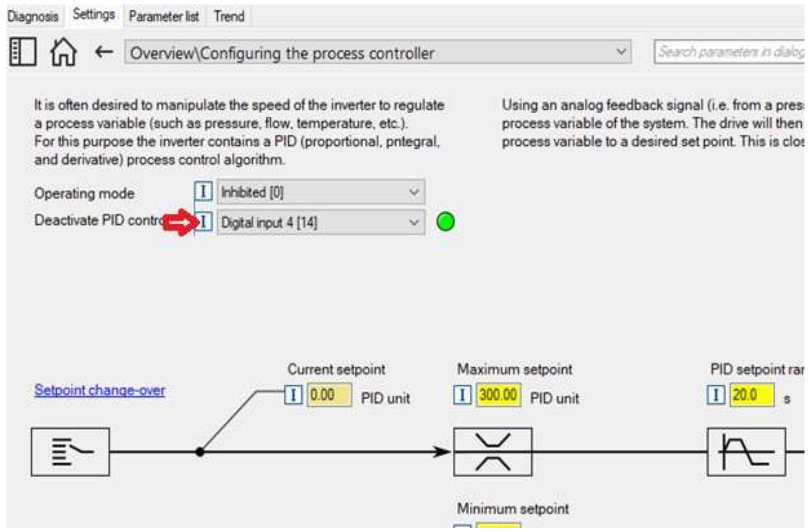
Set "Rinsing in sleep mode (P615:001)" to "Enabled [1]". Enter the time in minutes for how often the Rinse should be executed in "Rinse interval (P615:002)." Enter the "Rinse speed (P615:003)." Finally enter the time in seconds for how long the Rinse should last in "Rinse period (P615:004)."


Diagnosis
Settings
Parameter list
Trend
Overview\Configur...\Process controller - idle state and rinse function
Search parameters in dialogs
0/0
Disabled
Frequency setpoint < Frequency threshold (+Delay time)
Frequency setpoint < Frequency threshold (+Delay time) OR Current process variable > Feedback threshold (+Delay
Frequency setpoint < Frequency threshold (+Delay time) OR Current process variable < Feedback threshold (+Delay
Stop type
Coast to 0
Ramp to 0
Stop method
Frequency setpoint 0.0 Hz
Frequency threshold 20.0 Hz
Current process variable 0.00 PID unit
Feedback threshold 0.00 PID unit
Delay time 30.0 s
Bandwidth 0.00 PID unit
Recovery threshold 70.00 PID unit
Stop method Standard ramp [1]
Recovery
Frequency setpoint > Frequency threshold (+2Hz Hysteresis) OR PID error value > Bandwidth
Current process variable < Recovery threshold
Current process variable > Recovery threshold
Rinse function
This function accelerates the motor in idle state of the process controller at regular intervals to a defined speed.
A typical application for this function is the rinsing of a pipe system with a pump that has been in an inactive state for a longer period to prevent deposits.
Rinsing in sleep mod
Enabled [1]
PID sleep mode active
❶ Rinse interval 30.0 min
❷ Rinse speed 0.0 Hz
❸ Rinse period 0.0 s
f
t

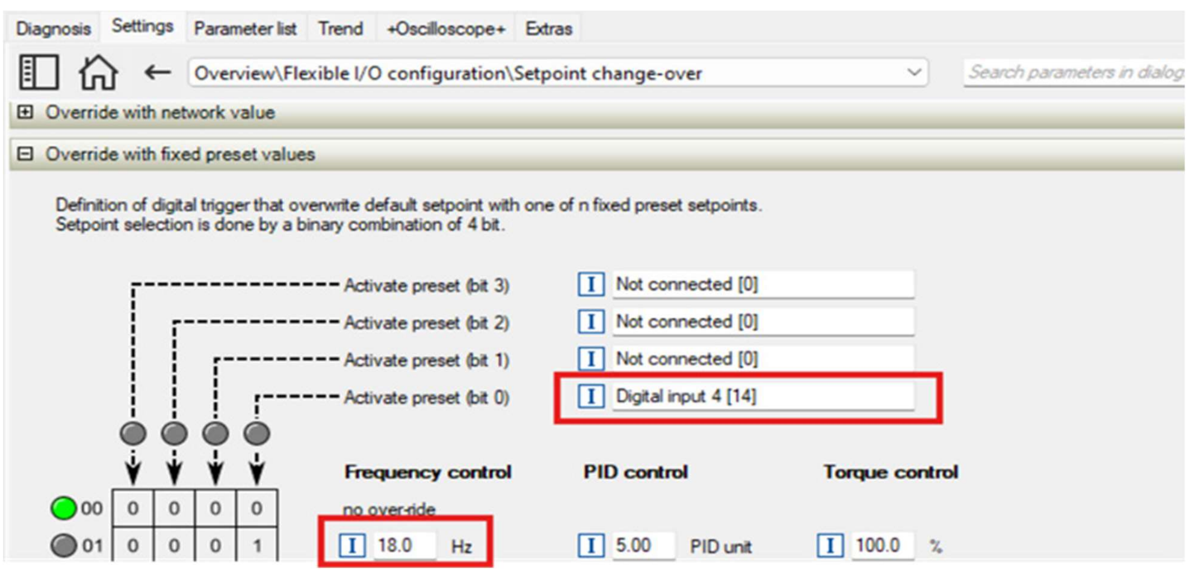
8 Purge (in PID applications)

Often in pumping applications that employ PID, a Purge function is desired to clear the lines (i.e., for cleaning in place). This function temporarily overrides the PID control and sets the pump to run at a predefined speed (usually full speed).

First, set “Deactivate PID controller (P400:045)” = to the desired Digital Input to trigger the Purge (i.e., “DI4 [14]”).



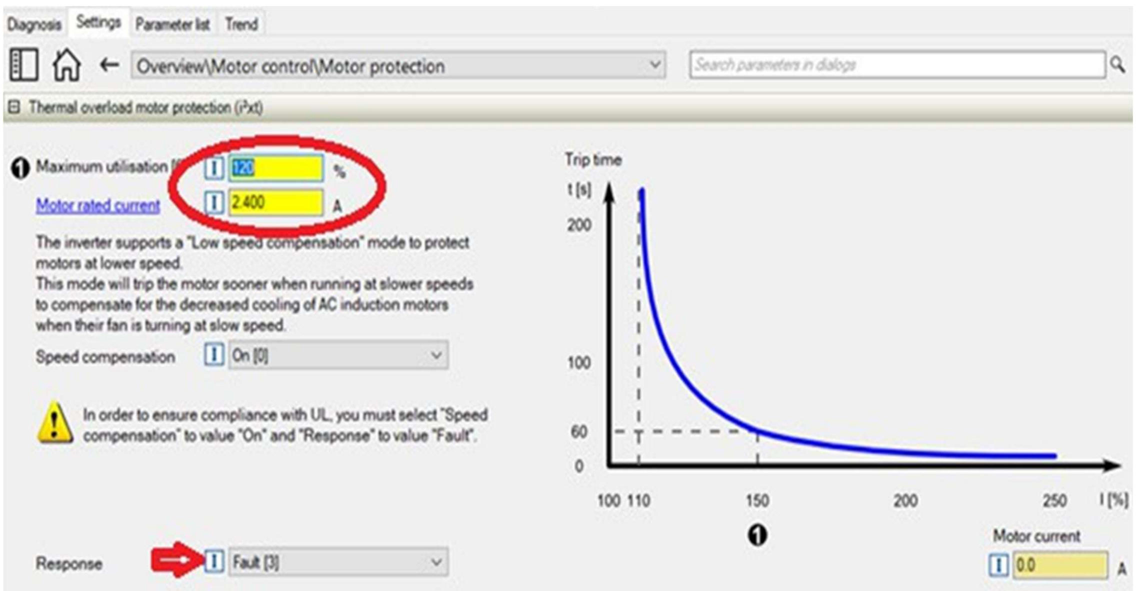
Next, set “Activate preset (bit 0) (P400:018)” to be triggered by the same Digital Input to trigger the purge (i.e., “DI4 [14]”). Finally, set the Purge speed (i.e., 60Hz) in “Preset 1 (P450:001)”.



9 Pump runout (or Zero head or Open flow) detection

Running a centrifugal pump with no (or insufficient) back pressure causes excessive flow and makes the pump run off its pump curve (very inefficient) at max available power. This condition often arises due to a pipe burst or the piping system not being completely installed (or someone could have left a drain open by mistake). *Note: Certain pumps used in the agricultural industry are designed to normally operate in this condition without issue.

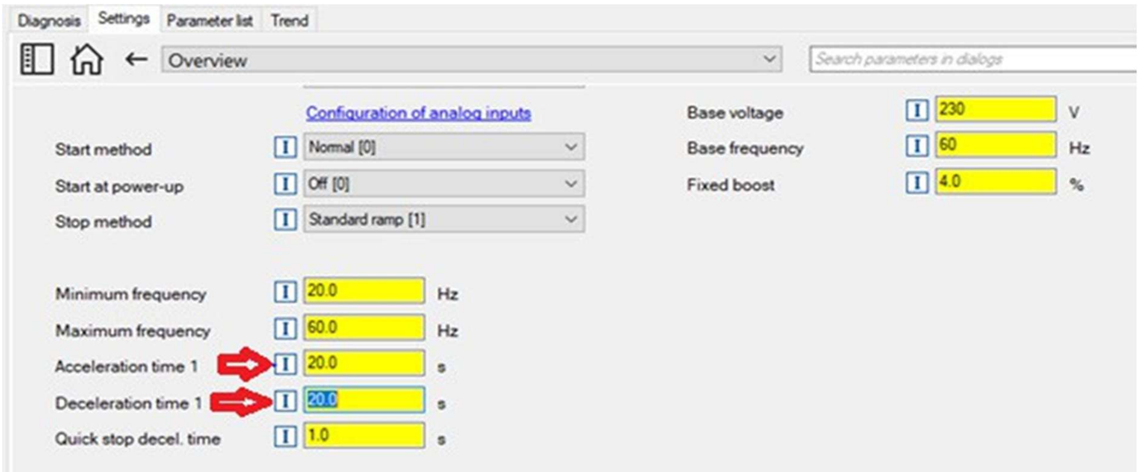
The drive's Motor overload setting can be used to detect and fault from this condition (and thereby prevent flooding) for most applications. Set the "Maximum utilization (60s) (P308:001)" = 120%. Set the "Motor rated current (P323:000)" to match the motor's nameplate data. Finally set the "Response (P308:003)" = "Fault [3]".



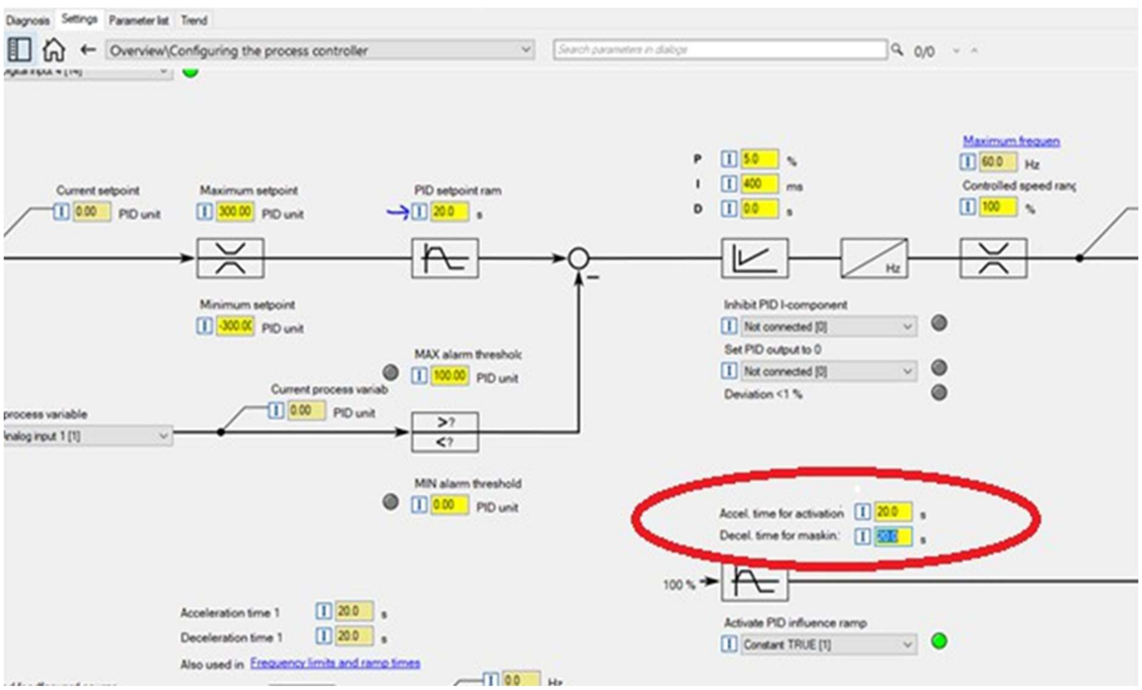
10 Water hammer minimization (and Pipe fill)

Fluid accelerating or decelerating too fast within a piping system can cause pressure shocks which can stress and damage the equipment and the piping system itself. These shocks are called "Water hammer." The i500 can help minimize this problem when the pump is changing speeds and also particularly when a pump is first started and pushing fluid into an empty piping system (Pipe Fill) by programming longer acceleration and deceleration times.

For applications not using PID, use longer times for both "Acceleration time 1 (P220:000)" and "Deceleration time 1 (P221:000)".



For applications utilizing PID, additionally use longer times for “PID setpoint ramp (P604:000)”, “Accel time of activation (P607:001)”, and Decel time for masking out (P607:002)”.



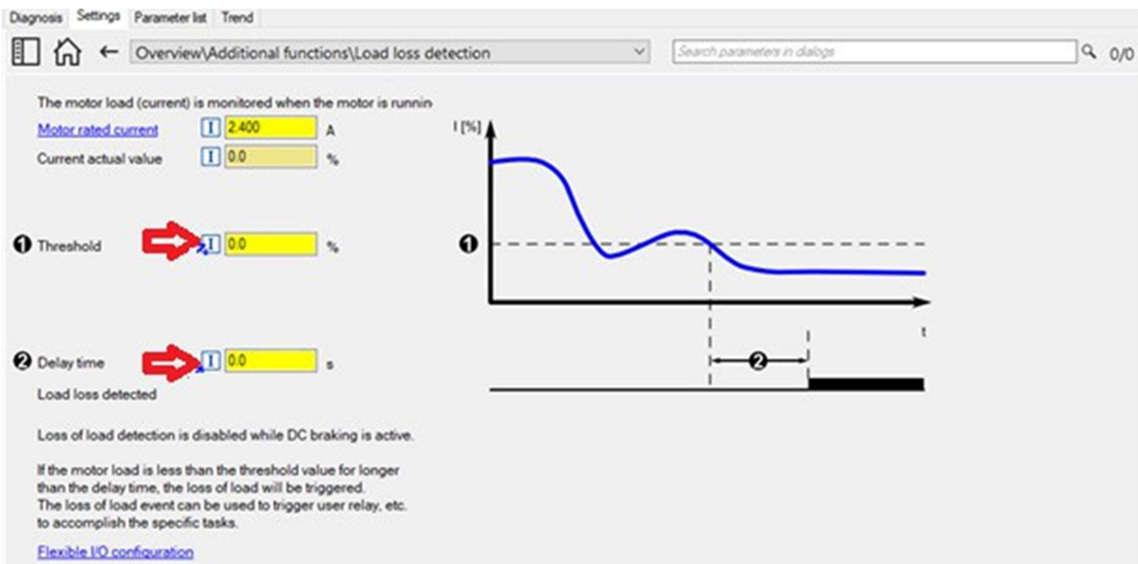
11 Cavitation prevention and Run dry (Loss of prime) protection

Centrifugal pumps should not be run without fluid in them. Doing so can cause the seals to heat and can damage them, as well as the motor and other components. This condition is called “Run dry” or is also referred to as “Loss of prime.” This condition can be detected via the same method used to prevent cavitation.

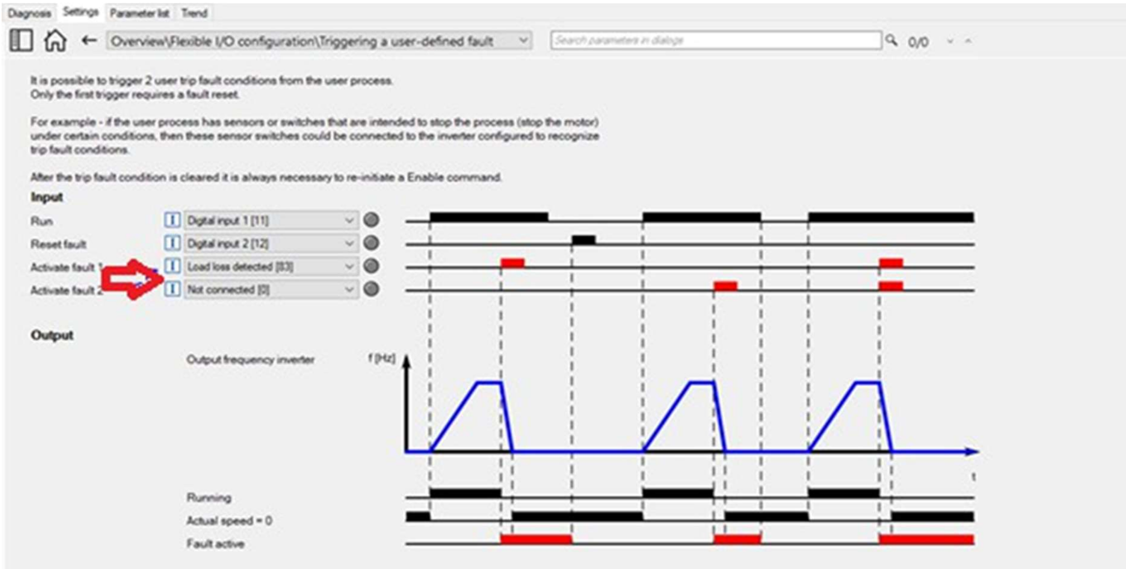
If the pump is always run at the same speed, a drop in NPSH can be detected as a drop in motor load.

First examine “Current actual value (P103.000)” while the pump is running in the system’s normal stable condition. Then lower the inlet pressure to cause cavitation and again observe “Current actual value (P103.000).” Determine a safe value between those two levels to account for variability of the system. Enter that value into “Threshold (P710.001).”

Next, we need to add some delay to the detection to prevent trips during startup or sudden changes due to opening/closing valves. Determine a safe time period and enter that into “Delay time (P710.002).”

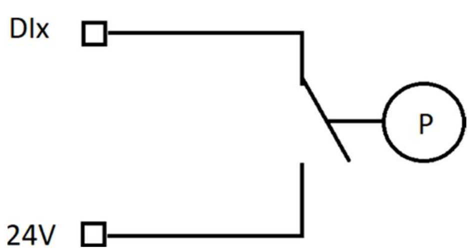


Next, assign either “Activate fault 1 (P400:043)” or “Activate fault 2 (P400:044)” to “Load loss detected [83]” to fault the drive with either “User-defined fault 1” or “User-defined fault 2” based upon the loss of NPSH.



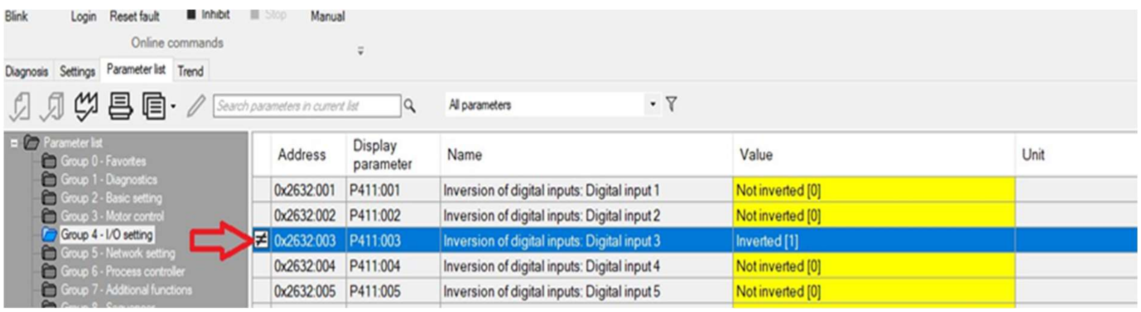
If the drive will be run at varying duty points, then an external pressure sensor must be used. The sensor needs to be installed into the application's process piping system upstream of the pump. Good practice is to install the sensor a distance upstream from the pump, equal to between 3 and 5 pipe diameters.

The most economical solution is to use a pressure switch (contact closure) that closes when the minimum required pressure is reached. Wire the switch between "24V" and one of the drive's digital inputs (i.e., DI3).



Next assign that DI as the trigger to either "Activate fault 1 (P400:043)" or "Activate fault 2 (P400:044)" to fault the drive with either "User-defined fault 1" or "User-defined fault 2" based upon the loss of NPSH.

As we need the open switch to trigger the fault the digital input's action must be inverted. Set P411.00x (x is the desired DI) = "Inverted [1]".



12 Cascade application (Multi and Booster pump application solution)

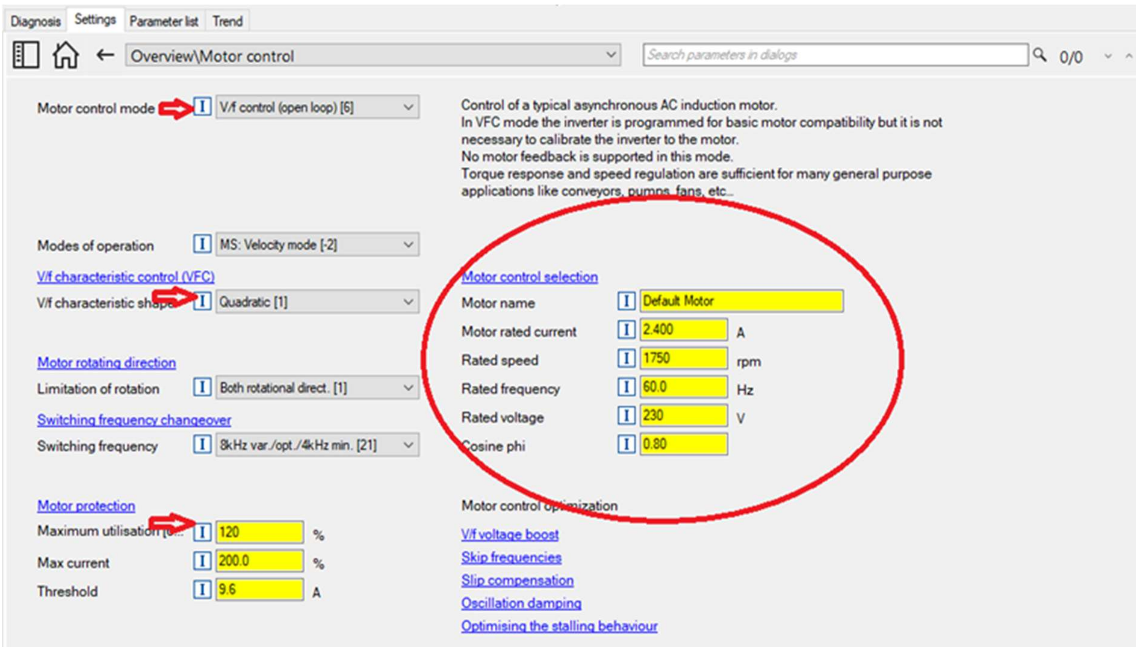
Some pump drives offer built-in logic to solve duplex and triplex pump applications. The i500 can be employed in these types of applications with the addition of an upper-level controller (such as the Lenze c430) that would perform the logical tasks and use the drives as I/O.

That being said, the i500 can be employed in a simple booster pump application without the addition of an upper-level controller. In this example system two i500 drives will be utilized. One to drive the main pump and another that will run the fixed speed booster pump. The first application consideration that must be noted is that the combination of both pumps (main and booster) must have more capacity than is required by the total system.

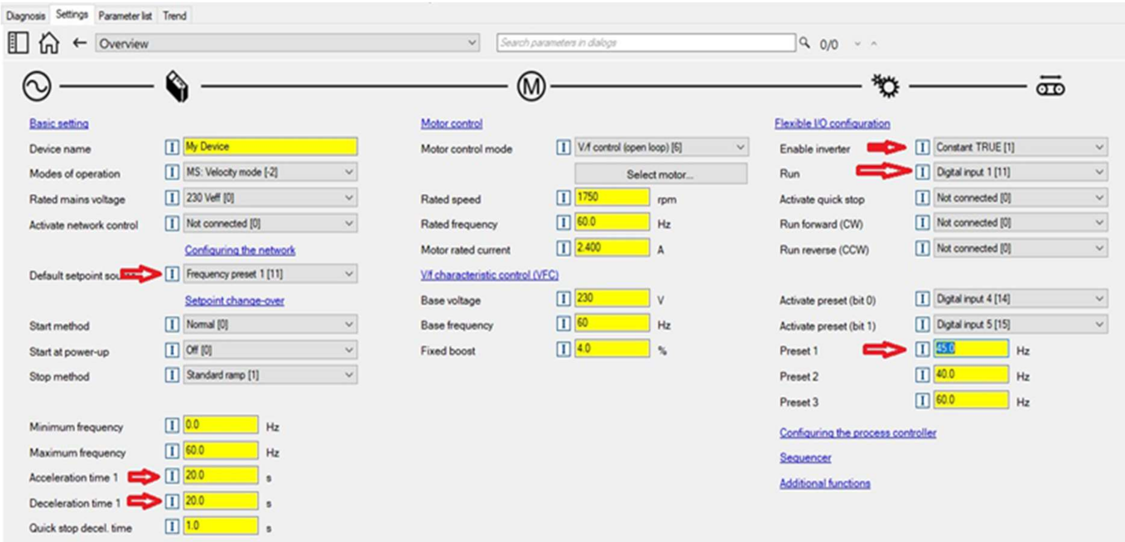
The second application consideration that must be noted is the main pump needs to have more capacity than the booster pump so that controllability of the system can be achieved. If both pumps are physically identical this can be achieved by running the booster pump at a slightly reduced speed (i.e., 45Hz).

Set up the booster pump's drive as follows:

- Set the "Motor control mode (P300:000)" to "V/f control (open loop) [6]".
- Set the "V/f characteristic shape (P302:000)" to "Quadratic [1]".
- Set the "Maximum utilization (P308:001)" to "120"%.
- Set the Motor data per the motor's nameplate.



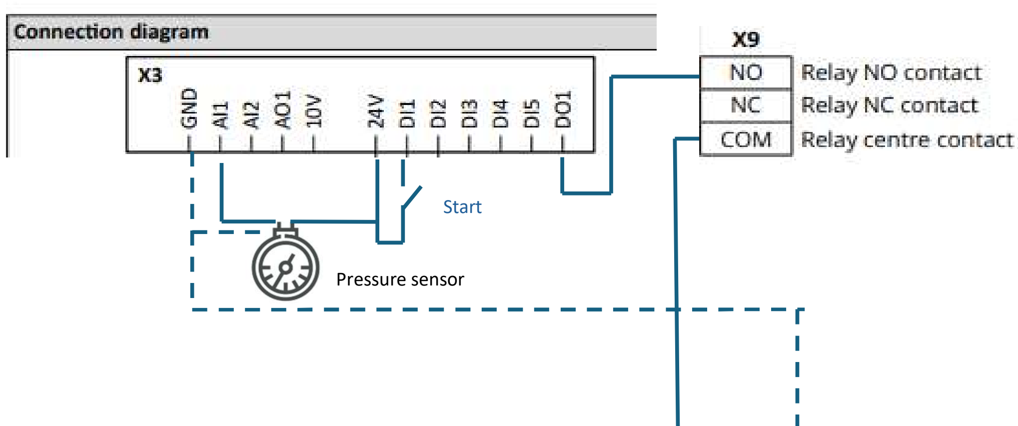
- Next, set the "Default setpoint source (P201:001)" to "Frequency preset 1 [11]".
- Set "Enable inverter (P400:001)" to "Constant TRUE [1]".
- Set "Run (P400:002)" to "Digital input 1 [11]".
- Enter an appropriate frequency into "Preset 1 (P450:001)" that ensures that both the combination of both the booster and main pumps' capacity exceeds the overall system capacity and is still a lower value so that the capacity of the booster pump is smaller than the capacity of the main pump (i.e. If both pumps are physically identical and both combined have sufficient capacity, then set the frequency to 45 Hz).
- Enter a long enough time into both "Acceleration time 1 (P220:000)" and "Deceleration time 1 (P221:000)" to ensure water hammer is minimized during pipe fill for system startup (i.e., 20 seconds).



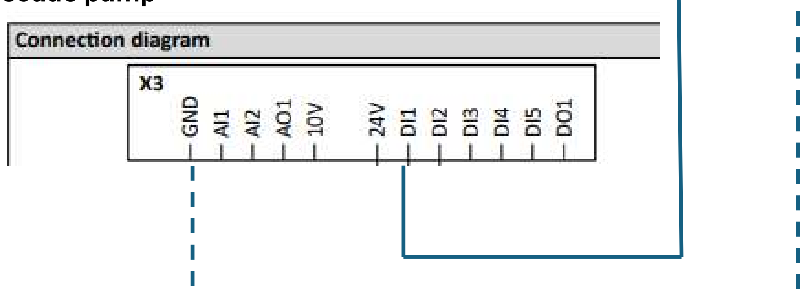
- Next, wire the booster pump's drive DI1 to be triggered by the combination of both the main pump's drive DO1 and Relay output. This will be a series circuit. We will use the combination of both outputs to ensure the booster is only turned on when called for by the main pump's drive and also to ensure the booster is not turned on if the main pump's drive is not running.

The wiring diagram is shown below:

Main pump drive

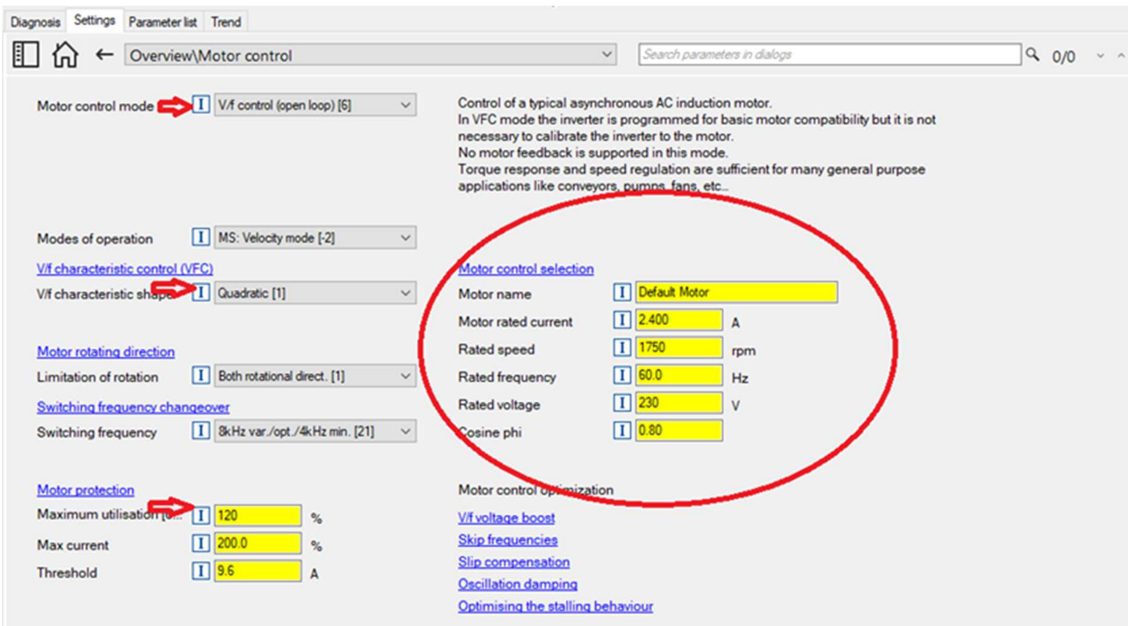


Cascade pump

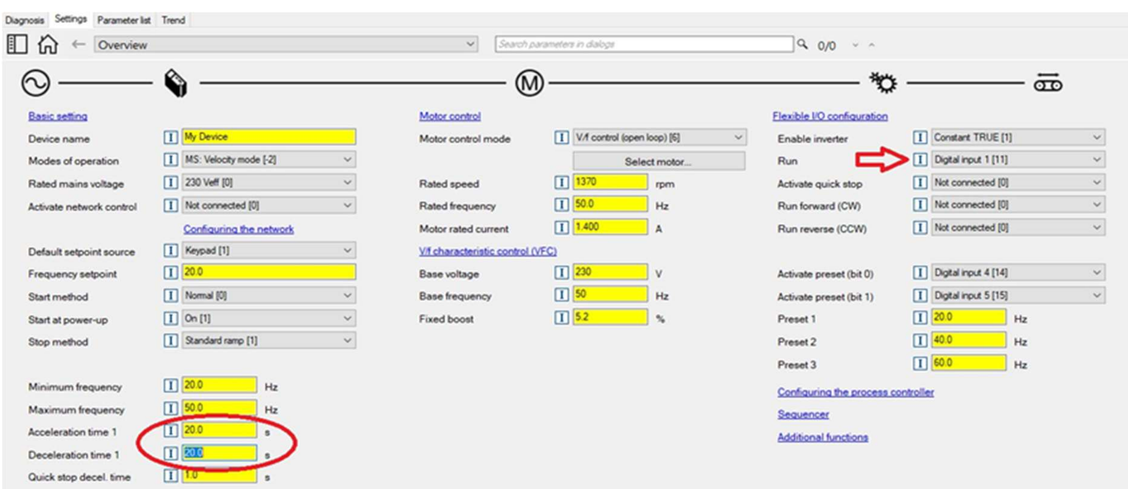


For the Main pump drive:

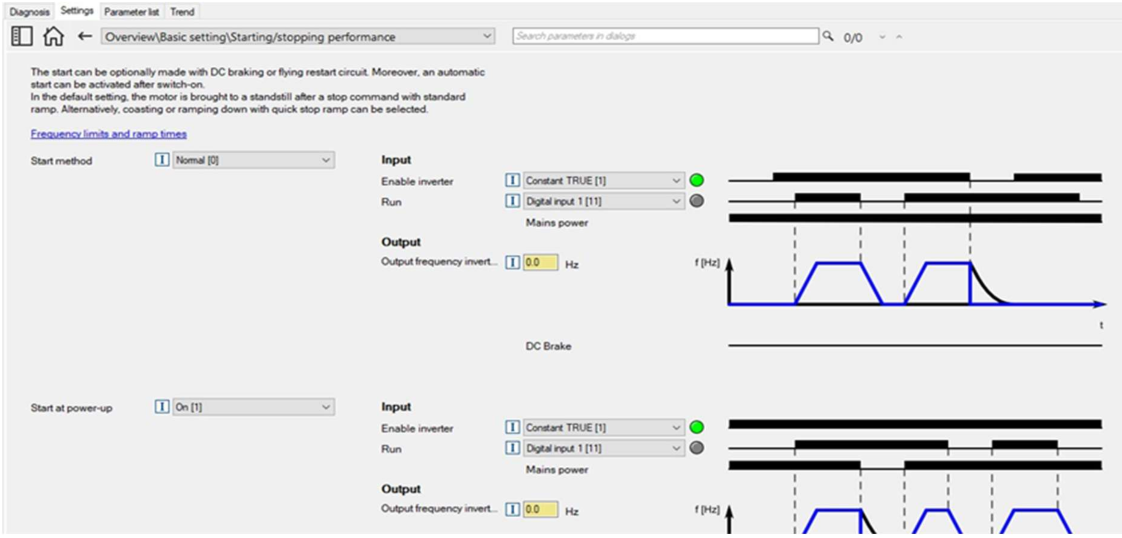
- Set the “Motor control mode (P300:000)” to “V/f control (open loop) [6]”.
- Set the “V/f characteristic shape (P302:000)” to “Quadratic [1]”.
- Set the “Maximum utilization (P308:001)” to “120”%.
- Set the Motor data per the motor’s nameplate.



- Next, set “Enable inverter (P400:001)” to “Constant TRUE [1]”.
- Set “Run (P400:002)” to “Digital input 1 [11]”. You will wire your system RUN/STOP contact to DI1 of the Main Pump Drive.
- Finally, enter a long enough time into both “Acceleration time 1 (P220:000)” and “Deceleration time 1 (P221:000)” to ensure water hammer is minimized during pipe fill for system startup (i.e., 20 seconds). Use the same value for these times as was entered in the Booster Pump Drive.

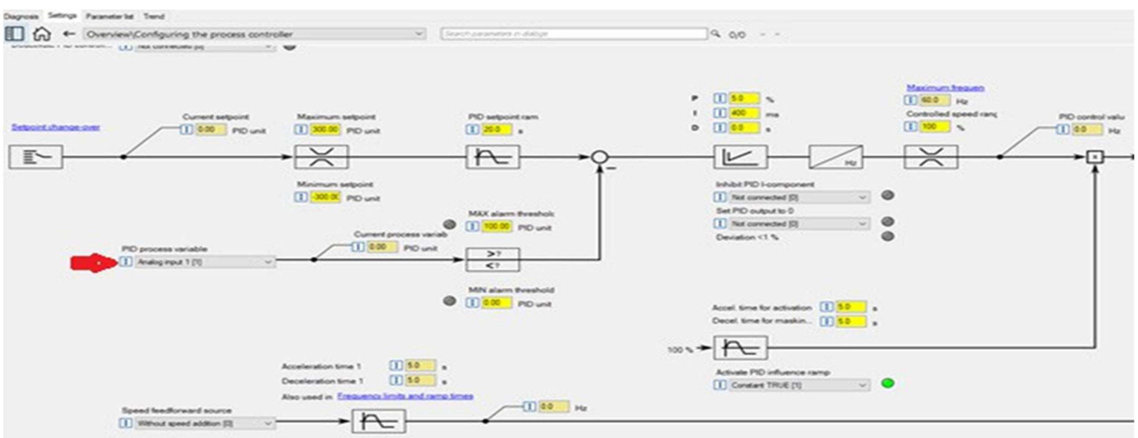


- Set “Start at power-up (P203:002)” to “On [1]”.

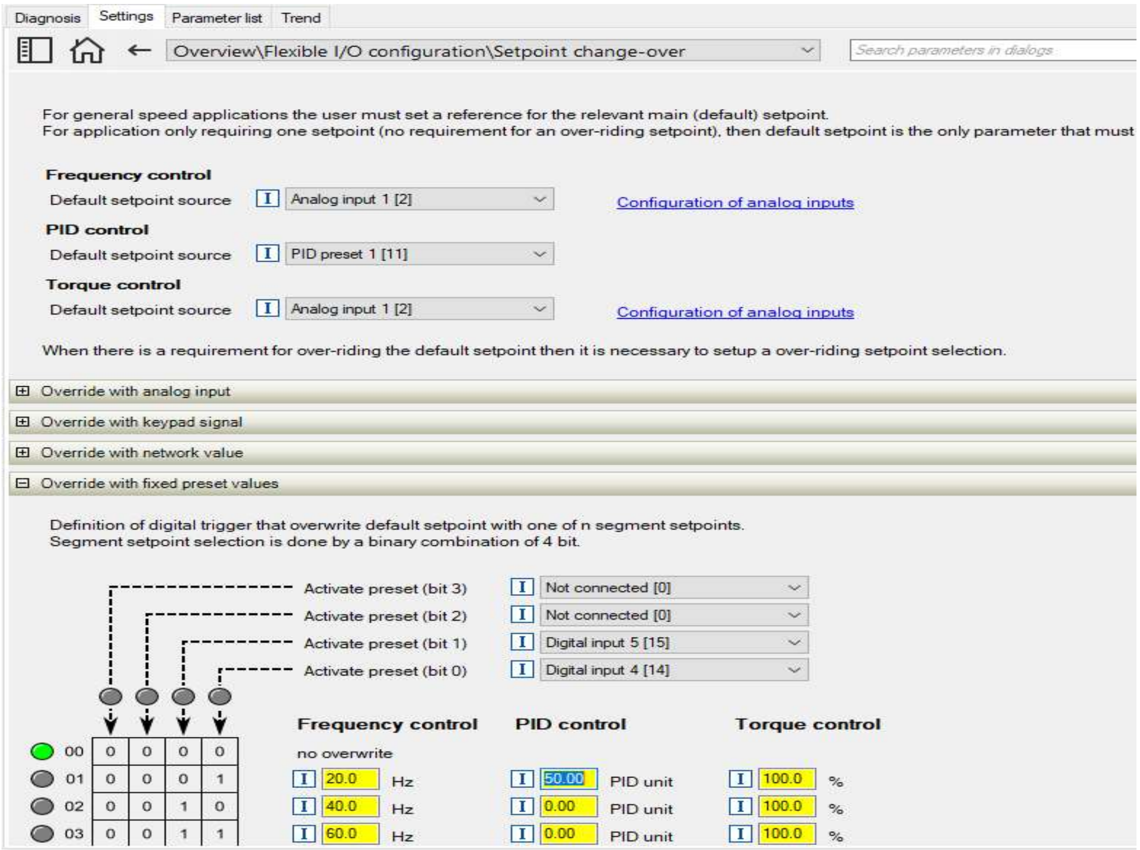


Now PID must be set up for the application:

- First, an appropriate analog sensor is installed into the system. Wire this pressure transducer to AIN1 of the Main Pump Drive. Pressure control from a centrifugal pump is a “normal acting” PID application.
- Set the “Operating mode (P600:001)” for “Normal operation [1]”.
- Next, we need to program which drive analog input will be used as the monitored process variable. Set “PID process variable (P600:002)” either equal to “Analog input 1 [1]”.

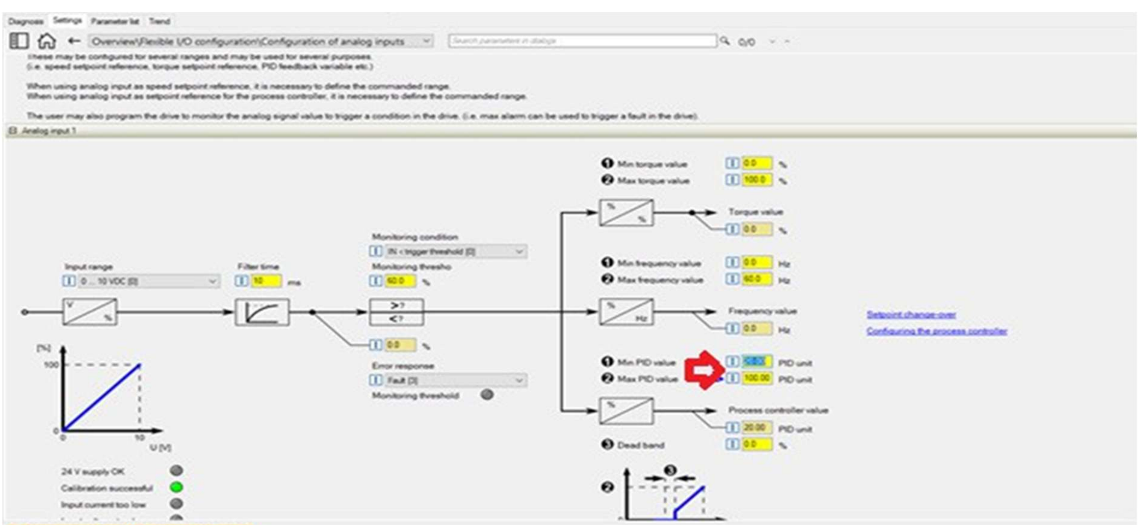


- Next, we need to program the drive for where the set point source is. The set point is the command value the drive is trying to get the monitored process variable to match. Set point sources can include the keypad, an analog signal (must not be the same analog input as the monitored process variable) or a predefined internal set point. Set “Default set point source (P201:002)” to one of the following selections as appropriate: “Keypad [1]”, “Analog input 2 [3]”, or “PID preset 1 [11]”. If you use “PID preset 1 [11]” as the set point, ensure you also program that desired set point value in “Preset 1 (P451.001)”.



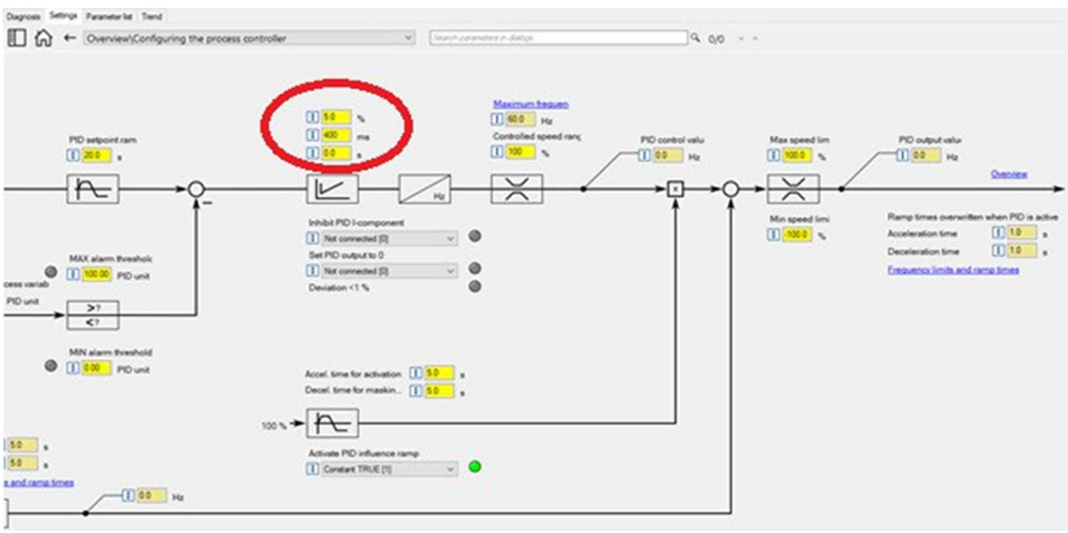
Please note the set point value is in User defined PID units, which in turn are configured in the monitored process variable's analog input channel configuration. Program both the "Min PID value (P43x:004)" and the "Max PID value (P43x:005)" to match the signal range of the analog sensor used to monitor the process variable. Enter this value in PID units (so if the sensor was 0-10VDC =

20-100PSI, set P43x:004 = 20.0 and P43x:005 = 100).



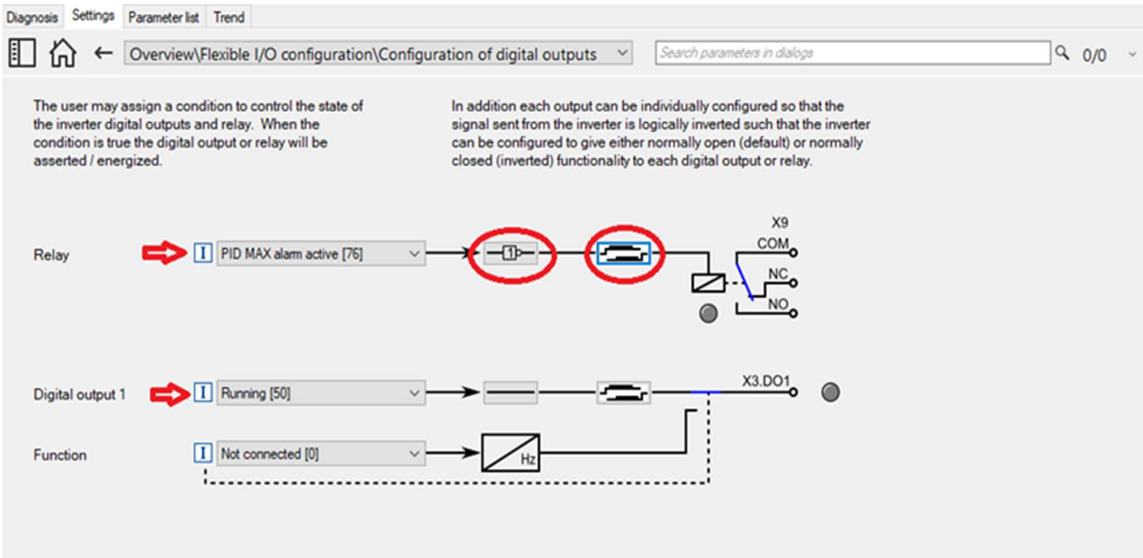
The PID loop must then be tuned on to the running system for the application. Do this under a load that can be sustained by the Main pump running alone. A common approach to PID tuning is the following.

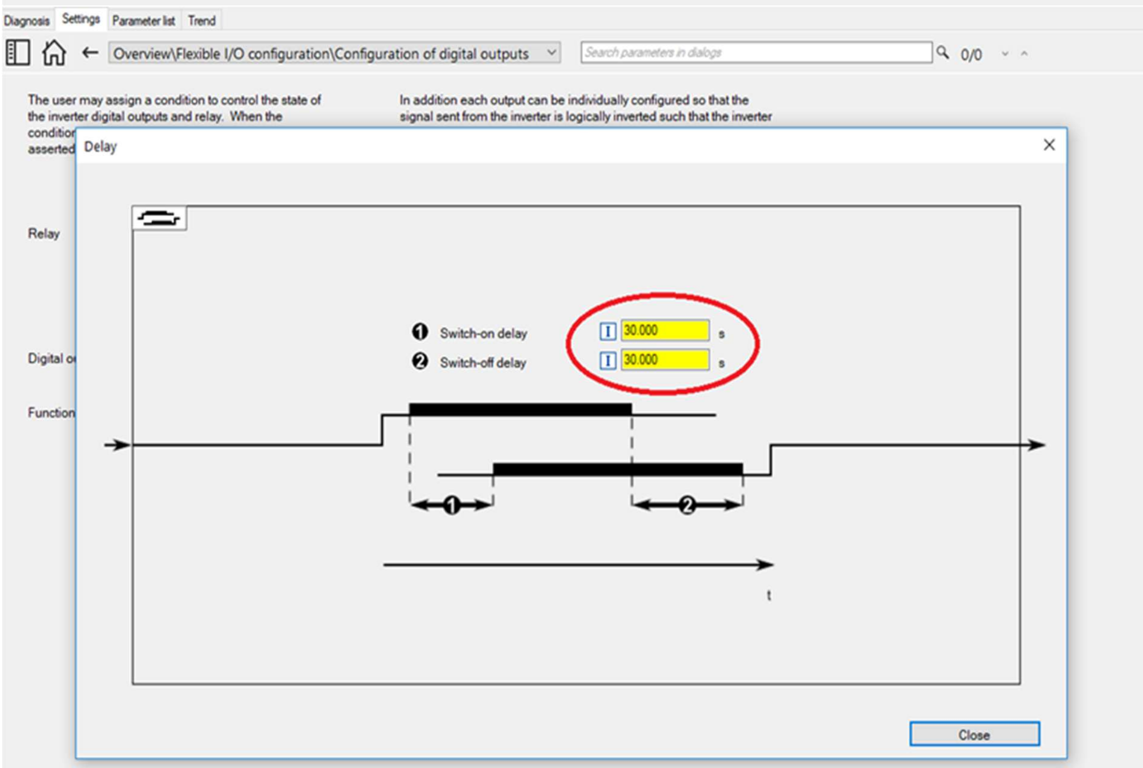
1. Set the reset time for the I component to 6000 ms in “PID I-component (P602.000)” to deactivate the I component. With this setting and the default setting of “PID D-component (P603.000),” the process controller operates as P controller.
2. Increase gain of the P component step by step in “PID P-component (P601.000)” until the system becomes unstable (oscillates).
3. Reduce the gain again until the system is stable again (stops oscillating).
4. Reduce the gain by another 15%.
5. Set reset time for the I component in “PID I-component (P602.000).” With this setting it should be noted that a too low reset time may cause overshoots, especially in case of high steps of the system deviation.
6. Optional: set the gain of the D component in “PID D-component (P603.000).”
7. With this setting it should be noted that the D component responds very sensitively to electrical noise disturbances on the feedback as well as digitization errors. For most systems, the “PID D-component (P603:000)” may be left at a value of 0. This is typically only required for extremely fast acting systems.



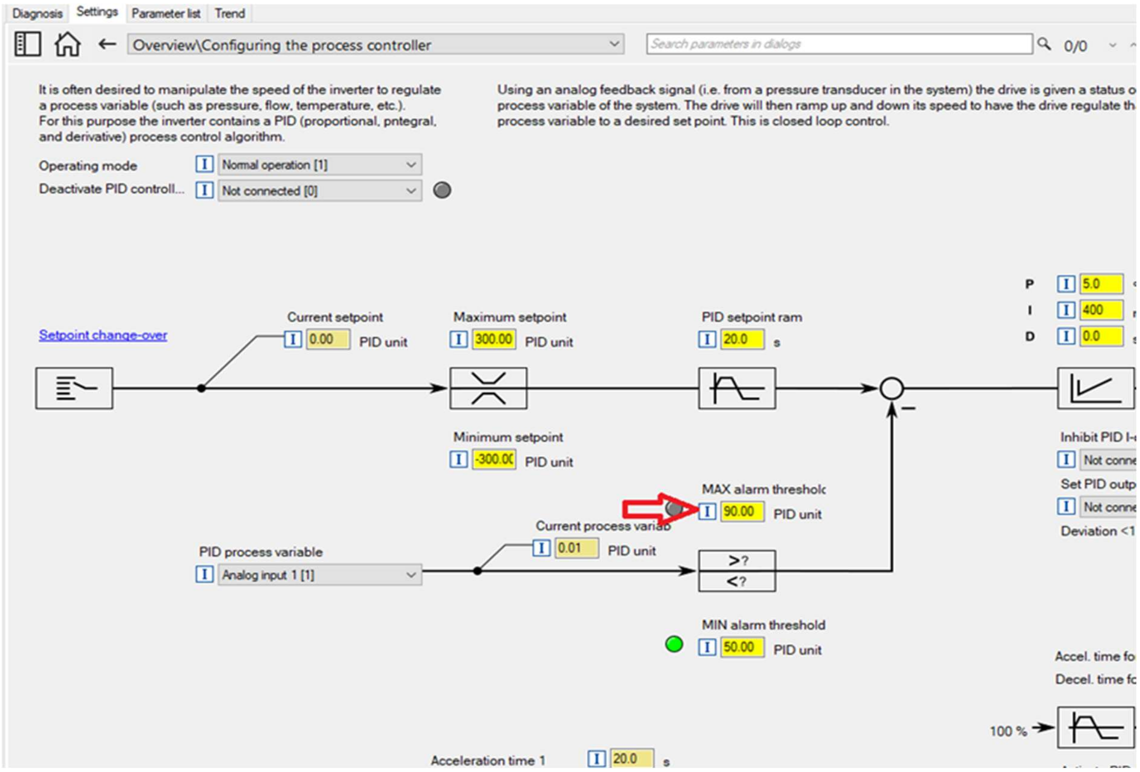
Now we must create the triggering conditions to control DO1 and the Relay output of the Main pump drive to start and stop the Booster Pump drive.

- Configure the “Digital outputs function: Relay (P420:001)” for “PID MAX alarm active [76]” also configure the “Inversion of digital outputs: Relay (P421:001)” to be “Inverted [1]”. This is a default setting, and we will be using parameter change over to switch the assignments to complete the application control in a later step.
- Set “Digital outputs function: Digital output 1 (P420:002)” to “Running [50]”.
- Set the “Relay: Switch on delay (0x4018:004)” and the “Relay: Switch off delay (0x4018:003)” to a value LONGER than that which was set for the “Acceleration time 1 (P220:000)” and “Deceleration time 1 (P221:000)”. Recommend the value be at least 50% more (so if Acceleration time 1 is set to 20 seconds, set the Switch on and switch off delays to at least 30 seconds). This is necessary to create a hysteresis and have controllability of the system.

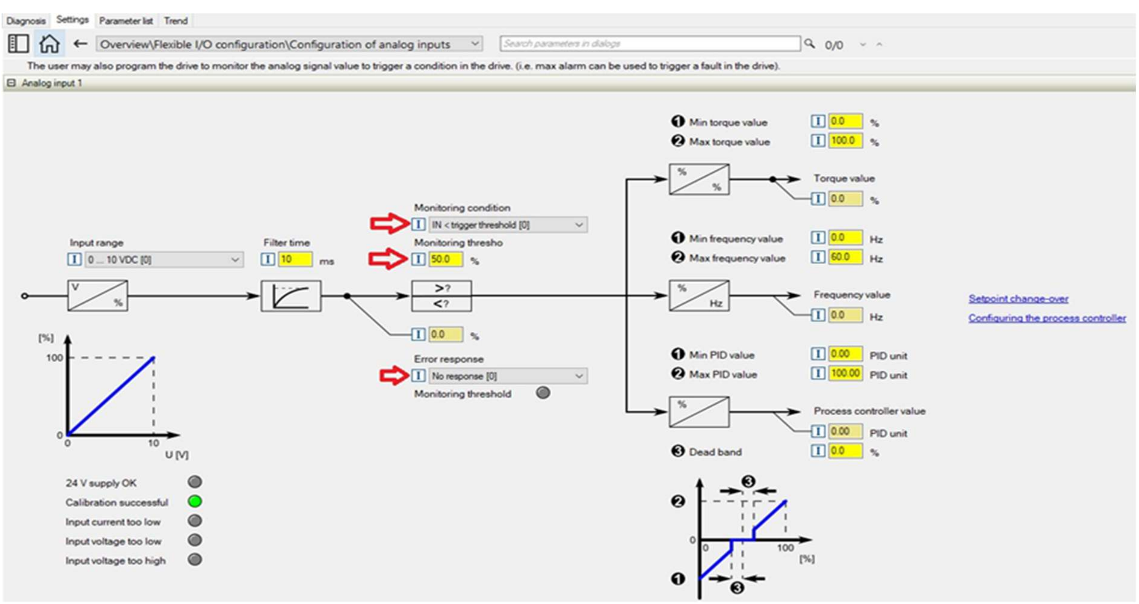




- Set the “MAX alarm threshold (P608:002)” to the highest level the system can tolerate above the set-point to define the pressure at which the Booster pump should turn off. This value is entered in PID units.



- Set the “Analog input 1: monitoring condition (P430:009)” to “IN< trigger threshold [0]”.
- Then set the value of the “Analog input 1: monitoring threshold (P430:008)” to the minimum allowable value for the pressure transducer to fall to in the application to define the point at which the Booster Pump should come on. Note: This value is set as a percentage of the Analog input 1’s overall range. It is NOT in PID units.
- Set the “Analog input 1: Error response (P430:010)” to “No response [0]”.



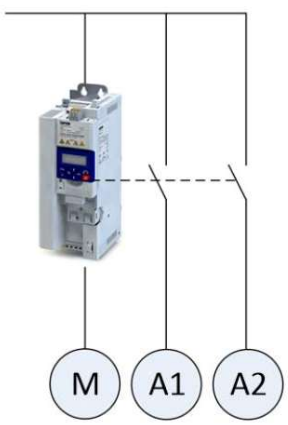
Lastly, the Parameter change-over function must be configured to achieve the control action. Set the following:

- “Activation of parameter set (P755:000)” = “Select. changed (immed) [3]”
- “Select parameter set (bit 0) (P400:041)” = “Error of analog input 1 [81]”
- Configure both the “Digital output function: Relay (P420:001)” and the “Inversion of digital outputs: Relay (P421:001)” parameters to be switched as shown below for BOTH “Value 1” and “Value 2”:

Cascade control with VFD and contactor control

This feature allows you to control multiple drives in fan and pump applications. The main drive is controlled by the inverter and the (maximum two) auxiliary drives are switched on directly via contactors if required. The main drive is controlled by the PID controller or another alternative setpoint source (digital/analog inputs, keypad, network) The switching cycles of the auxiliary drives are triggered depending on the actual load (PID controller).

Example with i550 cabinet frequency inverter:



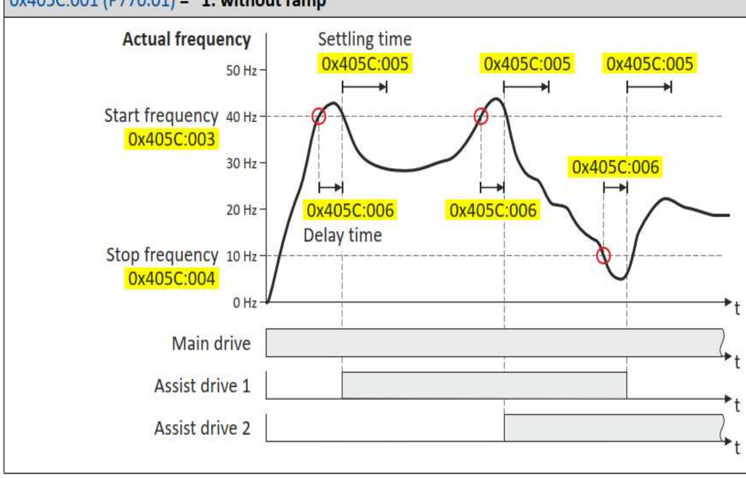
M	Main drive
A1	Auxiliary drive 1
A2	Auxiliary drive 2

Additional relays may be required to control the power contactors if the current/ voltage range from the relay/digital output is not sufficient for direct control.

Operating modes

Two operating modes are available for the cascade function, "without ramp" and "with ramp". The following diagrams illustrate the respective behavior.

0x405C:001 (P770.01) = "1: without ramp"

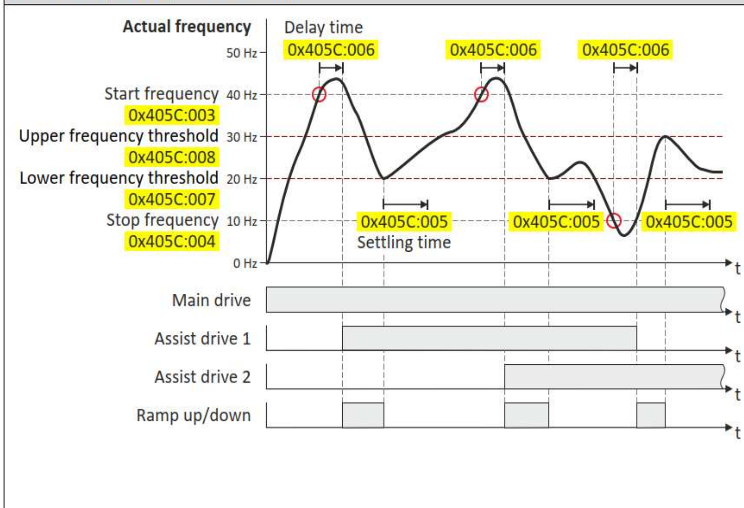


When the current frequency reaches the start frequency set in 0x405C:003 (P770.03), the delay time set in 0x405C:006 (P770.06) starts. The delay time is used to avoid unwanted on/off cycles.

After the delay time has elapsed:

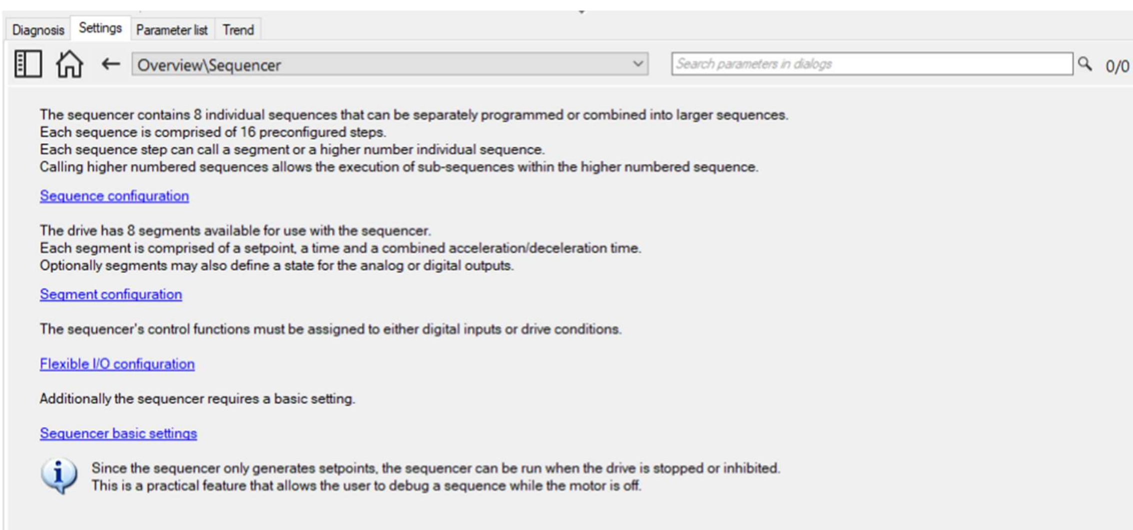
- The on/off command for the next auxiliary drive is set.
- The settling time set in 0x405C:005 (P770.05) starts.

During the settling time, no other auxiliary drive may be controlled by means of an on/off command. This time is also required so that the PID controller for the main drive can regulate itself again.

0x405C:001 (P770.01) = "2: with ramp"	
	When the current frequency reaches the start frequency set in 0x405C:003 (P770.03), the delay time set in 0x405C:006 (P770.06) starts. The delay time is used to avoid unwanted on/off cycles. After the delay time has elapsed: • The on/off command for the next auxiliary drive is set. • The frequency is reduced via a ramp to the lower frequency threshold set in 0x405C:007 (P770.07). When the current frequency reaches the lower frequency threshold, the settling time set in 0x405C:005 (P770.05) starts. During the settling time, no other auxiliary drive may be controlled by means of an on/off command. This time is also required so that the PID controller for the main drive can regulate itself again.

13 Sequenzer

The i500 features an internal advanced sequencer. This can be used to remove the need for supplementary controls in basic repetitive pumping processes. For details on this, see the i510 or i550 Commissioning manual.



The "sequencer" function serves to transfer a programmed sequence of setpoints to the motor control. The switch-over to the next setpoint can be made time-controlled or even-controlled. Optionally, the "sequencer" function can also trigger the digital and analog outputs.

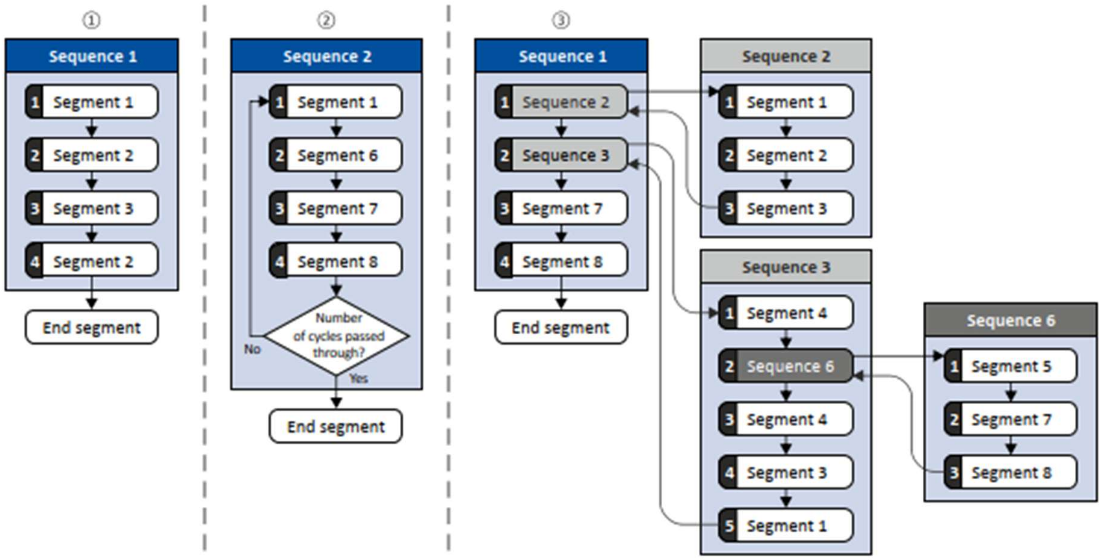
The sequencer only generates setpoints. However, the sequencer does not control the motor operation (does not output any start and stop commands). Versions with IO-Link do not offer this function.

Basics: Sequences, steps and segments

- Overall, sequences with the numbers 1 to 8 can be configured.
- Each sequence consists of 16 configurable steps.
- Each step of a sequence can call a "segment".

- A segment contains, among other things preset setpoints (speed setpoint, PID control value, torque setpoint), a combined acceleration/deceleration for the speed setpoint and optionally a configuration for the digital and analog outputs.
- 8 different segments and one end segment can be configured.

- Alternatively, to calling a single segment, a complete sequence (with a higher number) can also be called from one step. This serves to implement nested sequences or summarize several sequences to one sequence.



Commissioning

For commissioning the sequencer, we recommend the following proceeding:
1. Configure segments (including end segment).
   Details: ➧ Segment configuration page 101
2. Configure sequences:
   a) Assign the segments to the single steps of a sequence.
   b) Set the number of cycles for the respective sequence.
   Details: ➧ Sequence configuration page 111
3. Make the basic setting of the sequencer:
   a) Set the desired operating mode (time and/or step operation).
   b) Optionally adjust the sequence end mode and the sequence start mode.
   Details: ➧ Sequencer configuration page 115
4. Configure the control of the sequencer:
   a) Assign the functions for selecting a sequence to suitable triggers (e. g. digital inputs).
   b) Assign the functions for controlling the sequencer (start, stop, cancel, ...) to suitable triggers.
   Details: : ➧ Sequencer configuration page 118

Control

The sequencer can be controlled with the following function. For details, see chapter "Sequencer control functions" page 118

Function	Information
Select sequence (bit 0) ... Select sequence (bit 3)	Bit coded selection of the sequence to be started.
Start sequence	The selected sequence is started. The start can take place edge or status-controlled depending on the configuration.
Next sequence step	Immediate jump to the next step irrespective of the time set for the segment.
Pause sequence	The sequencer stops in the current step. The elapsing time set for the segment is stopped. The sequencer setpoint remains active.
Suspend sequence	There is a temporary return to the normal setpoint control. The sequence is then continued at the point where it was suspended.
Stop sequence	Direct jump to the end segment. The further execution depends on the selected end of sequence mode.
Abort sequence	Immediate return to the normal setpoint control. The end segment is not executed anymore.

Impeller Anti Jam

Impeller Anti Jam is a feature in some pump drives that will look for high motor currents at low speeds to determine if the impeller is jammed by some solid material. It may also perform a quick reversal to dislodge the jam. This is very commonly required for macerator pumps. **The i500 can perform the same function by means of its sequencer and current limit detection capabilities**. Below are the parameter settings to accomplish a basic impeller anti jam.

*Please note: For a macerator pump, "Motor control mode (P300:000)" should be set to "Sensorless Vector (SLVC) [4]" in order to manage the quick dynamic loading of the grinding operation.

Current Limit condition starts sequencer to run reverse 50Hz 0.5 seconds Accell/Decel = 1.0 second
End of sequence operation = continue to RUN

NOTE: Drive must be configured for FWD/REV rotation
"Limit of rotation (P304:000)" = "Both rotational direct [1]"

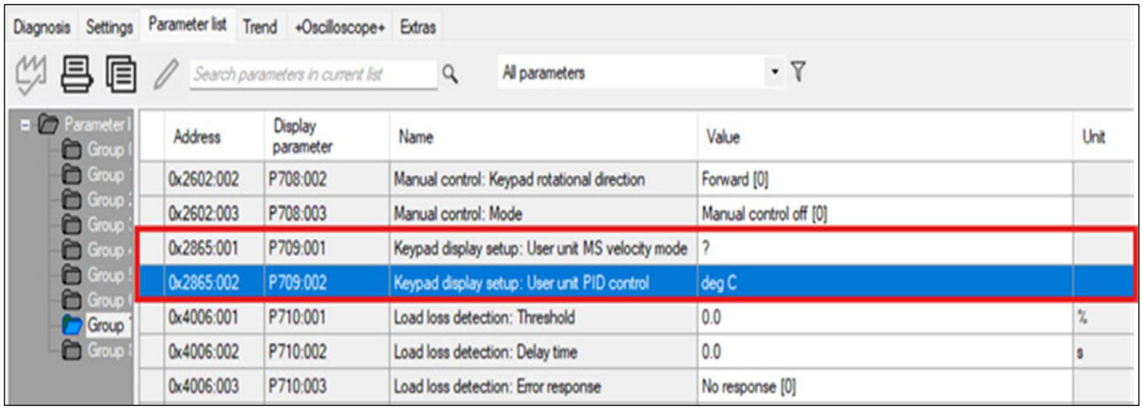
"Max current (P324:000)" = 1800 (decimal)
"Start sequence (P400:031)" = "Current limit reached [78]"
"Select sequence (bit 0) (P400:050)" = "Constant TRUE [1]"
"Sequencer mode (P800:000)" = "Time operation [1]"
"Sequencer Segment 1: Frequency setpoint (P801:001)"= "-50.0"
"Sequencer Segment 1: Accel/deceleration(P801:002)" = "1.0"
"Sequencer Segment 1: Time (P801:003)" = "1.0"
"End of sequence mode (P824:000)" = "Abort [3]"
"Sequence 1: Step 1 (P830:001)" = "Segment 1 [1]"
"Cycles Sequence 1 (P831:000)" = "1"

14 Keypad user units

The keypad for i500 cabinet series and i500 protec series drives may have the legend of the run screen changed to any 6 ASCII

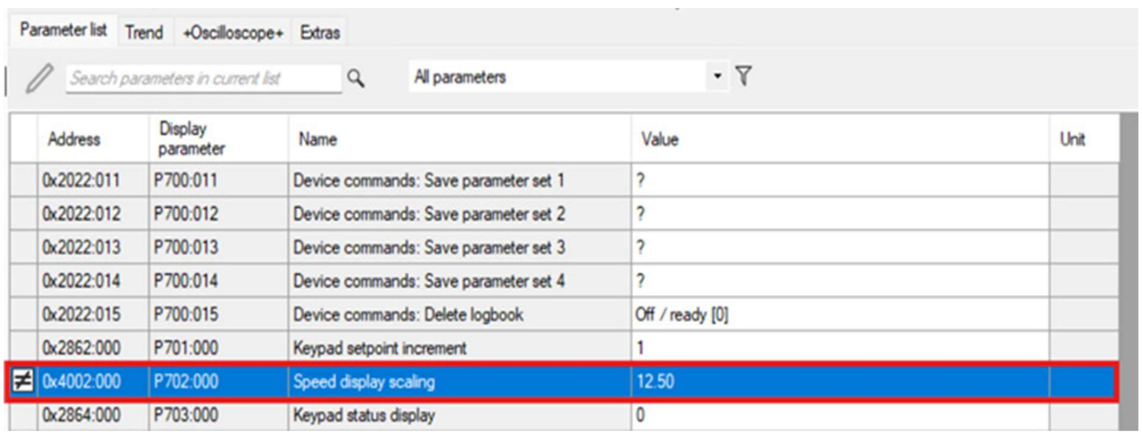
characters so that the display makes sense for the actual application (i.e., "deg F," "deg C," "ft/sec,' etc.). If the drive is in PID mode, set the legend in "User unit PID control" (0x2865:002 – P709:002).

If the drive is in velocity mode, set the legend in "User unit MS velocity mode" (0x2865:001 – P709:001).



Address	Display parameter	Name	Value	Unit
0x2602:002	P708:002	Manual control: Keypad rotational direction	Forward [0]	
0x2602:003	P708:003	Manual control: Mode	Manual control off [0]	
0x2865:001	P709:001	Keypad display setup: User unit MS velocity mode	?	
0x2865:002	P709:002	Keypad display setup: User unit PID control	deg C	
0x4006:001	P710:001	Load loss detection: Threshold	0.0	%
0x4006:002	P710:002	Load loss detection: Delay time	0.0	s
0x4006:003	P710:003	Load loss detection: Error response	No response [0]	

Also in velocity mode, program in a multiplier with “Speed display scaling” (0x4002:000 – P702:000) to convert Hz to the desired units (i.e., if 60Hz corresponds to 750 ft/sec, enter in a value of 12.50).



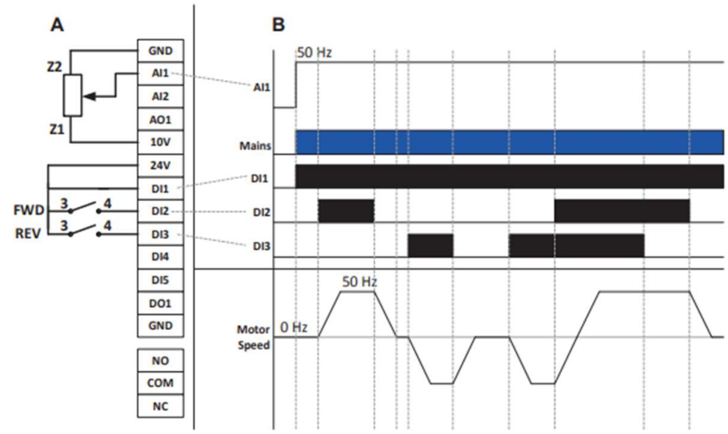
Address	Display parameter	Name	Value	Unit
0x2022:011	P700:011	Device commands: Save parameter set 1	?	
0x2022:012	P700:012	Device commands: Save parameter set 2	?	
0x2022:013	P700:013	Device commands: Save parameter set 3	?	
0x2022:014	P700:014	Device commands: Save parameter set 4	?	
0x2022:015	P700:015	Device commands: Delete logbook	Off / ready [0]	
0x2862:000	P701:000	Keypad setpoint increment	1	
0x4002:000	P702:000	Speed display scaling	12.50	
0x2864:000	P703:000	Keypad status display	0	

15 Switch/Potentiometer set

The switch/potentiometer set can be used to generate and supply simple control signals via standard I/O. This example shows a local 2-wire control of the inverter.

- The potentiometer is connected to analog input 1, which is configured as a setpoint source in the default setting. The potentiometer can be used to vary the frequency setpoint in the range from 0 Hz to the maximum frequency set in 0x2916 (P211.00).
- Switch in FWD position starts the motor in forward direction of rotation.
- Switch in REV position starts the motor in backward direction of rotation.
- Switch in 0 position stops the motor.

Local 2-wire control



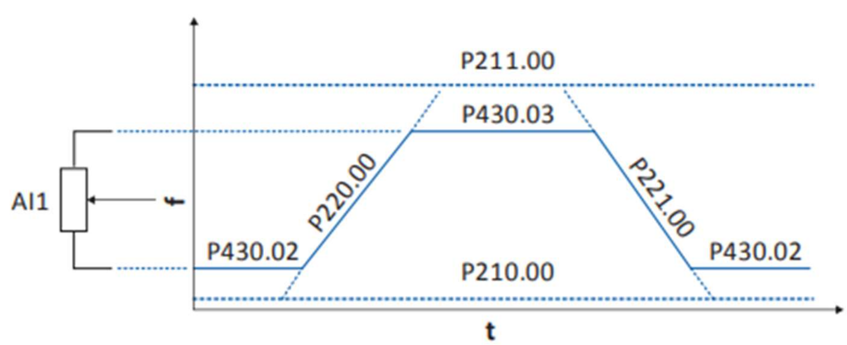
A 2-wire control
B Drive behavior
Z1/Z2 Potentiometer terminals
FWD 3/4, REV 3/4 Switch terminals

Commissioning

Setting parameters

1. Load default setting with**P700:1**.
2. Set the following parameters.

Display code	Name	Setting
P400.02	Run	Digital input 1 [11]
P400.04	Reset fault	Not connected [0]
P400.08	Run forward	Digital input 2 [12]
P400.09	Run reverse	Digital input 3 [13]
P400:13	Reverse rotational direction	Not connected [0]
P400.18	Setp: Preset b0	Not connected [0]
P400.19	Setp: Preset b1	Not connected [0]
P210.00	Min. frequency	Application specific
P211.00	Max. frequency	Application specific
P220.00	Acceleration time 1	Application specific
P221.00	Acceleration time 2	Application specific
P430.02	AI1 freq @ min	Application specific
P430.03	AI1 freq @ max	Application specific



16 Disclaimer

This guide is provided for informational purposes only. While every effort has been made to ensure the accuracy of the information, we cannot guarantee that it is free from errors or omissions. Users are advised to verify any information before relying on it. We accept no liability for any loss or damage caused by reliance on this guide.