# Lenze



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Figure 1 i550 protec IP66 / NEMA 4X





Figure 3 i550 cabinet IP20 / NEMA Open Type

Figure 2 i550 motec IP66 / NEMA 4X

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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]."

Diagnosis Settings Parameter	er list Trend Extras	
	w\Motor control	×
Motor control mode	Vf control (open loop) [6]	Control of a typical asynch in VFC mode the inverter i the inverter to the motor. No motor feedback is sup Torque response and spe conveyon, pumps, fans, e See "Motor Control Optimi
Modes of operation	MS: Velocity mode [-2]	
V/f characteristic control (	(FC)	Motor control selection
V/f characteristic shape	[ Quadratic [1]	Motor name
		Motor rated current

#### 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

Diagnosis Settings	Parameter list	Trend	+Oscilloscope+	Extras
□☆ ←	Overview\Ba	sic settir	ng\Starting/stop	ping performance
Start at power-up		0n [1]		_
Start at porter a	· L			

#### **Light Duty Mode**

The light duty mode is in general available on i5x0 cabinet  $\ge$  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.



Diagno	isis Se	ttings	Parameter list Trend +Oscilloscope+ Extras	
	厽	←	Overview\Motor Control\Switching frequency changeover	Search parameters in dialogs
9	elect the	switch	hing frequency:	
	Low	er swite	ching frequencies result in higher energy efficiency and reducing the leakage current.	
	High	ner swit	ching frequencies avoid hearing audible noise.	
Г	Fixe	d	-	
	04	kHz		
	08	8 kHz		
	0	2 kHz		
	0	l6 kHz		
	Varia	able, th	e inverter can switch to a lower frequency in case overload occurs	
İ.	02	2.4 kH	Z	
	02	28kH	2	
	02	212 kł	Hz .	
S	witching	freque	ency I 4 kHz fixed / min. Pv [16]	

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

Parameter list Tr	rend +Oscilloscope+	Extras					
/ duty			×	All parameters		• 7	
Address	Display parameter	Name			Value		Unit
≠ 0x2D43:001	P306:001	Inverter	load c	haracteristic: Duty selec	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.



ilable parameters					Select	led parameters	N
			× Parameter list	•	4	<b>4</b>	
Parameter list	Address	Display code	Name	*	-	-	
Group U - Favorites	0x2000:001			-	Pos.	Address	Name
Group 2 - Basic setting	0x2000:002	P190:002	Device data: Serial number		1	0x2DDD:000	Output frequency
Group 3 - Motor control	0x2000:004	P190:004	Device data: CU firmware version		2	0x6078:000	Current actual value
Group 4 - I/O setting	0x2000:005	P190:005	Device data: CU firmware type	1	3	0x2D89:000	Motor voltage
Group 6 - Process controller	0x2000:006	P190:006	Device data: CU bootloader version		4	0x603F:000	Error code
Group 7 - Additional functions	0x2000:007	P190:007	Device data: CU bootloader type		5	0x2824:000	Control selection
Group a - Sequencer	0x2000:008	P190:008	Device data: Object directory version		6	0x2860:001	Frequency control: Default setpoint source
	0x2000:010	P190:010	Device data: PU firmware version		7	0x2838:001	Start/stop configuration: Start method
	0x2000:011	P190:011	Device data: PU firmware type	-	8	0x2838:003	Start/stop configuration: Stop method
	0x2000:012	P190:012	Device data: PU bootloader version		9	0x2540:001	Mains settings: Rated mains voltage
	0x2000:013	P190:013	Device data: PU bootloader type		10	0x2915:000	Minimum frequency
	0x2000:014	P190:014	Device data: Module - firmware vers		11	0x2916:000	Maximum frequency
	0x2001:000	P191:000	Device name	1	12	0x2917:000	Acceleration time 1
	0x2002:004	P192:004	Device module: CU type code		13	0x2918:000	Deceleration time 1
	0x2002:005	P192:005	Device module: PU type code	T	14	0x2C00:000	Motor control mode
	0x2002:006	P192:006	Device module: CU serial number		15	0x2800:000	V/f characteristic shape
	0x2002:007	P192:007	Device module: PU serial number	•	16	0x2801:001	V/f shape data: Base voltage
	0x2006:000	P155:000	Error history buffer	-	17	0x2B01:002	V/f shape data: Base frequency

#### 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

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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.

Diagnosis occurigo	Parameter internu +Oscilloscope+ Extras
□☆ ←	Overview\Motor Control\Switching frequency changeover    Search parameters in dalogs
Select the switch	hing frequency:
Lower swite Higher swite	tching frequencies result in higher energy efficiency and reducing the leakage current. tching frequencies avoid hearing audible noise.
Fixed	
O 4 kHz	
○ 8 kHz	
◯ 12 kHz	r
◯ 16 kHz	1 1
Variable, the	he inverter can switch to a lower frequency in case overload occurs
O 2.4 kHz	łz
O 2.8kHz	łz
O 2.12kH	Hz
Reading parame	uden
Switching freque	ency 4 kHz fixed / min. Pv [16]

 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)

Diagnosis	Settings	Parameter list	Trend	+Oscilloscope+	Extras	
◧ 6	→ ն	Overview\Bas	sic settin	ig\Frequency lii	nits and ramp times	~
The fr freque carrie	equency rency setpo d out manu	ange can be limit int, two different Jally or automatic mum frequence	ted by set ramps ca cally.	tting a minimum a In be parameteris	nd maximum frequency. For the ed. Change-over to ramp 2 can be	
		<b>0</b> M I	inimum fr 10.0	equency Hz	Maximum frequency	

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

Diagnosis	Settings	Parameter list	Trend	+Oscilloscope+	Extras					
町よ	I A ← Overview\Basic setting\Frequency limits and ramp times									
The frequency range can be limited by setting a minimum and maximum frequency. For the frequency setpoint, two different ramps can be parameterised. Change-over to ramp 2 can be carried out manually or automatically.										
Minim	Minimum/maximum frequency									
		0	linimum fr	equency	A Maximum frequency					
		Ī	10.0	Hz	[ 60.0 Hz					
Acceleration/deceleration ramps										
		<b>S</b> A	cceleratio	on time	Deceleration time					
Stand	lard ramp	Ī	1.5	s	I 5.0 s					



- 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.

Diagnosis Settings Parameter list Trend +Oscilloscope+ Estras	Search parameters in dialogs	Q 0/0
Motor control mode  Sensori. contr. (SLSM-PSM) [8]	Control of a permanent magnet synchronous motor. In SLSM-PSM mode, the inverter is calil magnet motor (without feedback) which provides high torque response and accurate speed permanent magnet motors increases system efficiency by reducing motor losses associated asynchronous induction motors.	brated to the permanent regulation. The use of with the use of typical

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

Rated values from mo	tor nameplate				
Rated power	I 1.35	kW	Rated voltage	<b>I</b> 460	v
Rated speed	I 514	rpm	Rated frequency	<b>I</b> 60.0	Hz
Rated motor current	I 2.800	A	Cosine phi	<b>I</b> 0.90	
Additional data					
Overcurrent monitoring			Overspeed monitoring		
Threshold	I 16.8	A	Threshold	I 8000	rpm
			Max. motor speed	<b>I</b> 6075	rpm
Motor moment of inertia	<b>I</b> 90.00	kg cm <sup>2</sup>	Overspeed (0x6080) co	monitoring is inactive, d	lue to a lower Max motor speed

#### 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

D-axis inductance Ld	I 23.002	mH to FW Della	0x2C13-000	SLSM-low speed method	Carrier based [1]
Q-axis inductance Lq	I 35.425	mH			Carrier based [1] If based [2]

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.

Speed controller					0.00000	1
Scaled load inertia		kg cm²	Gain		0.00060	Nm/rpm
Coupling	g [] With backlash [2]		Reset time	I	800.0	ms
Actual speed filter time	I 2.0	ms	6b	)	Initialize	
<u>6a</u>				Ensure correct parameterization of curre controller, load and feedback system be initialized search controller actional.		eterization of current edback system befo



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.

] ☆ ← Overv	iew\Configuring the process controller		v	Search parameters in chalogs	م ۵٬۵ - ۰
It is often desired to man variable (such as pressur For this purpose the inve derivative) process contr	pulate the speed of the inverter to regulate a e, flow, temperature, etc.). ter cortains a PID [proportional, integral and of algorithm.	process	Using an analog feedback the system. The drive will t This is closed loop control.	signal §.e. from a pressure transducer in the system) then ramp up and down its speed to have the drive reg	he drive is given a status of a process variable of sulate that process variable to a desired set point.
Operating mode	1 Normal operation [1]	_			



### 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).

Diagnosis Settings Parameter list Trend +Oscilloscope+ Extras	
Cverview\Flexible I/O configuration\Setpoint chang	e-over   Search parameters in dialogs
Default setpoint source I Analog input 1 [2]	Configuration of analog inputs
PID control Default setpoint source I PID preset 1 [11]	
l orque control	
Default setpoint source I Analog input 1 [2]	Configuration of analog inputs
When there is a requirement for over-riding the default setpoint then it is nece	essary to setup a over-riding setpoint selection.
Override with analog input	
Override with keypad value	
Override with network value	
Override with fixed preset values	
Definition of digital trigger that overwrite default setpoint with one of n fixed po Setpoint selection is done by a binary combination of 4 bit.	reset setpoints.



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.

Dagnosis Settings Paramet	ter list Trend +Oscilloscope+ Extras	*	Search parameters in dialogs	Q, 0/0 ~ ~
It is often desired to manip variable (such as pressure For this purpose the invert derivative) process contro	vulate the speed of the inverter to regulate a pro , flow, temperature, etc.), er contains a PID (proportional, integral and ( algorithm.	cess Using an analog feedback the system. The drive will This is closed loop control	signal §.e. from a pressure transducer in the system) then ramp up and down its speed to have the drive re-	the drive is given a status of a process variable of guilate that process variable to a desired set point.
Operating mode	Normal operation [1]			
Disable PID controller	Not connected [0]	۲		
Select change over	Current setpoint	Maximum setpoint	PID setpoint rang	P 1 50 % I 1 400 mm D 1 00 %
	/	→ X	$- \not \rightarrow \rho$	

### 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.

Diagnosis Settings Parameter lis	t Trend	
	,	~
<u>ଲ</u>	- 🗞	
9		
Basic setting		Motor control
Device name	I My Device	Motor control n
Modes of operation	I MS: Velocity mode [-2] ~	
Rated mains voltage	I 230 Veff [0] ~	Rated speed
Activate network control	I Not connected [0] Vot	Rated frequence
	Configuring the network	Motor rated cur
Default setpoint source	I Analog input 1 [2]	V/f characteristi
	Configuration of analog inputs	Base voltage
Start method	I Normal [0] ~	Base frequency
Start at power-up	I Off [0] ~	Fixed boost
Stop method	I Standard ramp [1]	
Minimum frequency	<b>20.0</b> Hz	
Maximum frequency	I 60.0 Hz	
Acceleration time 1	I <mark>5.0</mark> s	
Deceleration time 1	I <mark>5.0</mark> s	
Quick stop decel. time	I 1.0 s	

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"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 car-

	л`	overview	(WOLDI CO	ntron/switching	frequency cr	langeover	
Selec	ct the switc	ning frequer	icy:				
	Lower swith Higher swit	ching freque ching freque	encies result encies avoid	n higher energy e hearing audible r	efficiency and r noise.	educing the leakag	e current.
	Fixed						
	⊖ 4 kHz						
	⊖8kHz						
1	O 12 kHz						
į,	O 16 kHz						
	Variable, th	e inverter c	an switch to	a lower frequency	y in case overlo	oad occurs	
	○ 2.4kH	z					
	○ 28 kH	z					
1	🔾 212 k	Hz					
Resu	ulting param	eter:					
Swite	ching freque	ency	I 16 kH	lz fixed / min. Pv	[18]		
	al ewitching	frequency	I				

rier 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			
Coverview\Configur\Process controller - idle state and rinse function      Search parameters in data	1/28	Q 0/0	~ ^
O Disabled	Frequency setpoint	1 0.0 Hz	t
Frequency setpoint < Frequency threshold (*Delay time)	Frequency threshold	I 20.0 Hz	1
O Frequency setpoint < Frequency threshold (*Delay time) OR Current process variable > Feedback threshold (*Delay	Current process variable	1 0.00 PI	Dunit
O Frequency setpoint < Frequency threshold (+Delay time) OR Current process variable < Feedback threshold (+Delay	Feedback threshold	I 0.00 PI	Dunit
Stop type	Delay time	I 30.0 s	
Coast to 0	Bandwidth	1 0.00 PI	Dunit
O Ramo to 0	Recovery threshold	I 70.00 Ptt	Dunit
O Stop method	Stop method	Standard ramp [1]	
Current process variable < Recovery threshold     Current process variable > Recovery threshold			
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 Rinsing in sleep mode active	period to prevent deposits.		_
Rinse period		' '-@'	+

### 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)".

Diagnosis Settings Parameter list Trend +Oscilloscope+	Extras		
E ☆ ← Overview\Flexible I/O configuration\S	etpoint change-over	~	Search parameters in dialog
Override with network value			
Override with fixed preset values			
Definition of digital trigger that overwrite default setpoint with Setpoint selection is done by a binary combination of 4 bit.	one of n fixed preset setpoints.		
Activate preset (bit 3)	Not connected [0]		
Activate preset (bit 2)	I Not connected [0]		
Activate preset (bit 1)	I Not connected [0]		
Activate preset (bit 0)	Digital input 4 [14]		
<b>• • • •</b>			
Frequency control	PID control	Torque control	
O0 0 0 0 0 no over-ride			
● 01 0 0 0 1 1 18.0 Hz	I 5.00 PID unit	I 100.0 %	

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### 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)".

Diagnosis Setting	9 Parameter list	Tren	d					
□☆←	Overview				~	Search param	eters in dialogs	
			Configuration of analo	a inputs	Base voltage		I 230	v
Start metho	d	Ι	Normal [0]	~	Base frequency		I 60	Hz
Start at pow	er-up	Ι	Off [0]	~	Fixed boost		I 4.0	%
Stop metho	d	Ι	Standard ramp [1]	~				
Minimum fr	equency	I	20.0 Hz					
Maximum fr	equency	Ι	60.0 Hz					
Acceleration	time 1 📫	I	20.0 s					
Deceleratio	n time 1 📫	I	20.0 s					
Quick stop of	lecel, time	Ι	1.0 s					

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)".



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### 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]".

	-					
Blink Login Reset fault	innipit III	Stop Manual				
Online co	ommands		÷			
Diagnosis Settings Parameter list	Trend					
1 1 4 B E	Search par	rameters in current	list Q	All parameters • 💎		
Parameter list     Group 0 - Favortes		Address	Display parameter	Name	Value	Unit
Group 1 - Diagnostics		0x2632:001	P411:001	Inversion of digital inputs: Digital input 1	Not inverted [0]	
Group 3 - Motor control	1.1	0x2632:002	P411:002	Inversion of digital inputs: Digital input 2	Not inverted [0]	
Group 4 - I/O setting		0x2632:003	P411:003	Inversion of digital inputs: Digital input 3	Inverted [1]	
Group 5 - Network setting	er	0x2632:004	P411:004	Inversion of digital inputs: Digital input 4	Not inverted [0]	
- Group 7 - Additional functi	ions	0x2632:005	P411:005	Inversion of digital inputs: Digital input 5	Not inverted [0]	

### 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).

**Application Guide** 

# Pumps and Pump Systems | Lenze VFDs

#### 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.

Control of a typical asynchronous AC induction motor. In VEC mode the inverter is programmed for basic motor compatibility but it is not necessary to calibrate the inverter to the motor. No motor feedback is supported in this mode. Torque response and speed regulation are sufficient for many general purpose applications like conveyors, purpose fains, etc.   Modes of operation MS: Velocity mode [-2]   Vif characteristic control (VFC)   Vif characteristic shape   Motor rotation direct.   Limitation of rotation   Both rotational direct.   Switching frequency   I BkHz var./opt /4kHz min.	Diagnosis Settings Parameter	r list Trend			
Motor control mode       I Vf control (open loop) [6]       Control of a typical asynchronous AC induction motor.         In VFC mode the inverter is programmed for basic motor compatibility but it is not necessary to calibrate the inverter to the motor.       No motor feedback is supported in this mode.         No motor feedback is supported in this mode.       Torque response and speed regulation are sufficient for many general purpose applications like conveyors, purpose frame speed regulations are sufficient for many general purpose applications like conveyors, purpose frame speed regulations         Modes of operation       I MS: Velocity mode [2]       Vf         Vif characteristic control (VFC)       Vif characteristic shape       I Quadratic [1]       Vfoor control selection         Motor rotation       I Both notational direct. [1]       Vif characteristic shape       I Default Motor         Motor rotation of rotation       I Both notational direct. [1]       Vif characteristic shape       I 1750       rpm         Switching frequency       I BitHz var./opt //4kHz min. [21]       Vif cosine phi       I 080       Vif 080	II A ← Overvi	ew\Motor control		Search parameters in dialogs	Q 0/0 ~ ^
Modes of operation       I       MS: Velocity mode [-2]       Vif characteristic control (VFC)         Vif characteristic schemet I       Duadratic [1]       Motor name       I         Motor rotating direction       I       Both rotational direct. [1]       Motor rated current       I         Switching frequency       I       Both rotational direct. [1]       Motor rated requency       I       60.0       Hz         Switching frequency       I       BkHz var/opt /4kHz min. [21]       Cosine phi       I       0.80	Motor control mode	V/f control (open loop) [6]	<ul> <li>Control of a typical asyn In VFC mode the inverted necessary to calibrate the No motor feedback is s Torque response and s applications like converted</li> </ul>	Actronous AC induction motor. is programmed for basic motor compatibility but it is no he inverter to the motor. upported in this mode. peed regulation are sufficient for many general purpose yors, pumps fans, etc	a
Vif characteristic control (VFC)       Motor control selection         Vif characteristic shape 1       Quadratic [1]       Motor name       1         Motor rotating direction       I       Both rotational direct. [1]       Motor rated current       1       2400       A         Switching frequency       I       Both rotational direct. [1]       Motor rated current       1       750       rpm         Switching frequency       I       Both rotational direct. [1]       Rated speed       1       750       rpm         Switching frequency       I       Both rotational direct. [1]       Cosine phi       1       0.80       1	Modes of operation	MS: Velocity mode [-2]	~		
V/f characteristic shape       I Quadratic [1]       V       Motor name       I Default Motor         Motor rotating direction       II       Both rotational direct. [1]       V       Motor rated current       I 2400       A         Switching frequency chanageover       II       Bit Hz var./opt //4kHz min. [21]       V       Rated voltage       I 230       V         Switching frequency       II       Bit Hz var./opt //4kHz min. [21]       V       Ossine phi       I 080	V/f characteristic control	(VFC)	Motor control selection		
Motor rotating direction       Imitation of rotation       Imitation of r	V/f characteristic shape	Quadratic [1]	<ul> <li>Motor name</li> </ul>	I Default Motor	
	Motor rotating direction Limitation of rotation Switching frequency ch.	Both rotational direct. [1] angeover     Beth year /oet /dirth min [2]]	Motor rated current Rated speed Rated frequency Rated voltage	1     2400     A       1     1750     rpm       1     60.0     Hz       1     230     V	
Motor protection Motor control Operation	Motor protection	I oknz var./opt./eknz min. [21]	Motor control observation	ion	
	Maximum utilisation	T 120 %	Vifueltage boost		
Max current     I     200.0     %     Skip frequencies       Threshold     I     9.6     A     Oscillation damping       Optimising the stalling behaviour	Max current Threshold	1         200.0         %           1         9.6         A	Skip frequencies Slip compensation Oscillation damping Optimising the stalling	behaviour	

- 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).

Diagnosis Settings Parameter list	Trend						
□ ☆ ← Overview		✓ Search,	parameters in dialogs		Q 0/0 ~ ^		
0	<b>\$</b>	(	D		*o		<b>b</b>
Basic setting		Motor control			Elexible I/O configuration		
Device name	1 My Device	Motor control mode	V/f control (or	pen loop) [6] 🗸 🗸	Enable inverter	Constant TRUE [1]	~
Modes of operation	MS: Velocity mode [-2]	~	s	elect motor	Run 🥪	Digital input 1 [11]	$\sim$
Rated mains voltage	1 230 Veff [0]	<ul> <li>Rated speed</li> </ul>	1 1750	rpm	Activate quick stop	Not connected [0]	~
Activate network control	1 Not connected [0]	<ul> <li>Rated frequency</li> </ul>	1 60.0	Hz	Run forward (CW)	I Not connected [0]	~
	Configuring the network	Motor rated current	1 2.400	A	Run reverse (CCW)	Not connected [0]	~
Default setpoint sou	Frequency preset 1 [11]	Vf characteristic control	(VEC)				
	Setpoint change-over	Base voltage	1 230	v	Activate preset (bit 0)	I Digital input 4 [14]	~
Start method	I Normal [0]	<ul> <li>Base frequency</li> </ul>	1 60	Hz	Activate preset (bit 1)	I Digital input 5 [15]	~
Start at power-up	I Off [0]	<ul> <li>Fixed boost</li> </ul>	1 4.0	- N	Preset 1 🖘	• [] <u>650</u> Hz	
Stop method	Standard ramp [1]	~			Preset 2	1 40.0 Hz	
					Preset 3	[] 60.0 Hz	
Minimum frequency	I 0.0 Hz				Configuring the process cor	otroller	
Maximum frequency	I 60.0 Hz				Sequencer		
Acceleration time 1 📫	s 1 20.0 s				Additional functions		
Deceleration time 1 📫	▶ [] 20.0 s						
Quick stop decel. time	1 1.0 s						

• 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



#### For the Main pump drive:

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- 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.

Diagnosis Settings Parameter list Trend	
Cverview\Motor control	✓ Search parameters in dialogs Q 0/0 ✓ ∧
Motor control mode 📬 🚺 V/f control (open loop) [6] 🗸 🗸	Control of a typical asynchronous AC induction motor. In VFC mode the inverter is programmed for basic motor compatibility but it is not necessary to calibrate the inverter to the motor. No motor feedback is supported in this mode. Torque response and speed regulation are sufficient for many general purpose applications like conveyors. pumps. fans. etc.
Modes of operation I MS: Velocity mode [-2]	
V/f characteristic control (VFC)	Motor control selection
V/f characteristic shape 1 Quadratic [1]	Motor name I Default Motor
Motor rotating direction           Limitation of rotation         I Both rotational direct. [1]           Switching frequency changeover           Switching frequency         I & Hz var /opt. / 4kHz min. [21]	Motor rated current     I     2400     A       Rated speed     I     1750     rpm       Rated frequency     I     60.0     Hz       Rated voltage     I     230     V       Cosine phi     I     0.80
Motor protection         Maximum utilisation         Max current         I         200.0         %         Threshold         9.6         A	Motor control optimization <u>Vif voltage boost</u> <u>Skip frequencies</u> <u>Slip compensation</u> <u>Oscillation damping</u> <u>Optimising the stalling behaviour</u>

- 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.

Diagnosis Settings Parameter list	Trend								
I ☆ ← Overview			<ul> <li>✓</li> </ul>	oarameters in d	daloga		Q 0/0 ∨ ^		
$\odot$ —	Ŷ		(	0—			*0	ē	Ď
Basic setting			Motor control				Flexible I/O configuration		
Device name	My Device		Motor control mode	I VA	control (oper	n loop) [6] 🗸 🗸	Enable inverter	Constant TRUE [1]	~
Modes of operation	MS: Velocity mode [-2]	$\sim$			Sel	ect motor	Run	Digital input 1 [11]	~
Rated mains voltage	1 230 Veff [0]	~	Rated speed	I 137	70	rpm	Activate quick stop	Not connected [0]	~
Activate network control	Not connected [0]	$\sim$	Rated frequency	I 50.0	0	Hz	Run forward (CW)	I Not connected [0]	~
	Configuring the network		Motor rated current	I 1.4	00	A	Run reverse (CCW)	Not connected [0]	~
Default setpoint source	Keypad [1]	~	VII characteristic control	(VEC)					
Frequency setpoint	I 20.0		Base voltage	I 230	0	v	Activate preset (bit 0)	Digital input 4 [14]	~
Start method	I Normal (0)	~	Base frequency	I 50		Hz	Activate preset (bit 1)	I Digital input 5 [15]	~
Start at power-up	I On [1]	~	Fixed boost	I 52		<b>N</b>	Preset 1	1 20.0 Hz	
Stop method	Standard ramp [1]	~					Preset 2	1 40.0 Hz	
							Preset 3	1 60.0 Hz	
Minimum frequency	1 20.0 Hz						Configuring the process co	ntroller	
Maximum frequency	I 50.0 Hz						Sequencer		
Acceleration time 1	1 20.0 5						Additional functions		
Deceleration time 1	1 800								
Quick stop decel. time	I 10 s								

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

Diagnosis Settings Parameter list Trend					
□ ☆ ← Overview\Basic setting\Sta	arting/stopping performance	✓ Search parameters in dalogs		Q 0/0 ~ ^	
The start can be optionally made with DC brai start can be activated after swith/>-on. In the default setting, the motor is brought to a ramp, Alternatively, coasting or ramping down Frequency limits and ramp times	king or flying restart circuit. Moreover, an automatic a standstill after a stop command with standard with quick stop ramp can be selected.				
Start method I Normal [0]	<ul> <li>Input</li> </ul>				
	Enable inverter	Constant TRUE [1]	~ O		
	Run	Digital input 1 [11]	~ O		-
		Mains power			
	Output				
	Output frequency inve	н. [] <mark>0.0</mark> Нz	f [Hz]		-
		DC Brake			-
Start at power-up I On [1]	<ul> <li>✓ Input</li> </ul>				
	Enable inverter	Constant TRUE [1]	~ •		-
	Run	Digital input 1 [11]	~ <b>O</b>		-
		Mains power		1 I I I I	-
	Output		101.1		
	Output frequency inve	Hz	1 [P12]		

#### 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)".

Diagnosis Settings	Parameter list	Trend				
□☆ ←	Overview\Fl	exible I/O configuration\	Setpoint change-over	~	Search parameters in dialogs	
For general spee For application o	d application nly requiring o	s the user must set a refere one setpoint (no requirement	nce for the relevant main (o nt for an over-rid <mark>ing setpoir</mark>	default) setpoint. tt), then default se	stpoint is the only parameter that must	
Default setpoint	Default setpoint source T Analog input 1 [2]					
PID control						
Default setpoint	source I	PID preset 1 [11]	~			
Torque contro	ı					
Default setpoint	source I	Analog input 1 [2]	<ul> <li>Configurati</li> </ul>	on of analog inpu	its	
When there is a r	equirement fo og input ad signal	or over-riding the default set	point then it is necessary to	o setup a over-rid	ing setpoint selection.	
Definition of dig Segment setpoi	ital trigger than the selection is	t overwrite default setpoint v done by a binary combinat	with one of n segment setp ion of 4 bit.	oints.		
 I		- Activate preset (bit 3)	I Not connected [0]	~		
[		- Activate preset (bit 2)	I Not connected [0]	~		
	[	<ul> <li>Activate preset (bit 1)</li> </ul>	I Digital input 5 [15]	~		
		<ul> <li>Activate preset (bit 0)</li> </ul>	I Digital input 4 [14]	~		
¥ ¥	¥ ¥	Frequency control	PID control	Torque co	ntrol	
0 00 0	0 0	no overwrite				
01 0 0	0 1	I 20.0 Hz	I 50.00 PID unit	I 100.0 9	6	
02 0 0	1 0	I 40.0 Hz	I 0.00 PID unit	I 100.0 9	6	
03 0 0	1 1	I 60.0 Hz	I 0.00 PID unit	I 100.0 9	6	

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.

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- 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 setpoint to define the pressure at which the Booster pump should turn off. This value is entered in PID units.

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- 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:

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- "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:



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.

- M Main drive
- A1 Auxiliary drive 1
- A2 Auxiliary drive 2





### 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:

- 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]"

### 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).



Diagnosis Settings	Parameter list Tr	end +Oscilloscope+	Extras		
Ÿ 8 6	Search par	rameters in current list	Q. All parameters	• 7	
Parameter I	Address	Display parameter	Name	Value	Unit
Group (	0x2602:002	P708:002	Manual control: Keypad rotational direction	Forward [0]	
Group :	0x2602:003	P708:003	Manual control: Mode	Manual control off [0]	
Group -	0x2865:001	P709:001	Keypad display setup: User unit MS velocity mode	?	
Group !	0x2865:002	P709:002	Keypad display setup: User unit PID control	deg C	
Group	0x4006:001	P710:001	Load loss detection: Threshold	0.0	%
Group (	0x4006:002	P710:002	Load loss detection: Delay time	0.0	8
	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).

Pa	arameter list Tr	rend +Oscillosco	pe+ Extras		
6	Search pa	arameters in current	All parameters	• 7	
	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.

lenze







B Z1/Z2 FWD 3/4, REV 3/4

Local 2-wire control

Drive behavior Potentiometer terminals 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	Al1 freq @ min	Application specific
P430.03	Al1 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.