PID FUNCTION
in Delta VFD-EL for water pressure control

CONTENTS:

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1 GENERAL

1.1 Application

AC Motor Drives are more and more and widely applied in water supply systems for households, buildings and industry. With an AC Motor Drive, water pressure can be controlled conveniently in various applications. When the water flow demand changes; e.g. opening a tap or taking a shower, an AC Motor Drive can be used to control the pump's speed; thus matching the water flow to the demand and saving energy at the same time. Apart from energy-saving, an AC Motor Drive also has the following additional advantages:

1. Avoid inrush current during power up and maintain the stability of the mains power supply, because the starting current can be limited to the AC Motor Drive's rated current.
2. Lengthen the lifetime of pumps and valves due to the lower average rotation speed of the pump.
3. Avoid water hammer effects during starting and stopping.

The basic method of a constant pressure water supply system is that water the supply controller (commonly known as PID controller) outputs an analogue signal, based on the actual water pressure, to control the AC Motor Drive. Delta VFD-EL series AC Motor Drive (multiple functions/micro type, power range 200W~3.7kW) has a built-in constant pressure water supply controller, which enables a constant pressure water supply in a very convenient and more economical way. This example is for Delta VFD-EL series AC Motor Drive in single pump applications for constant pressure water supply, which are widely used in households, motels, spa's, etc. Apart from energy-saving in constant pressure water supplies as is common with AC Motor Drives, Delta VFD-EL series AC Motor Drive also has the following extra advantages:

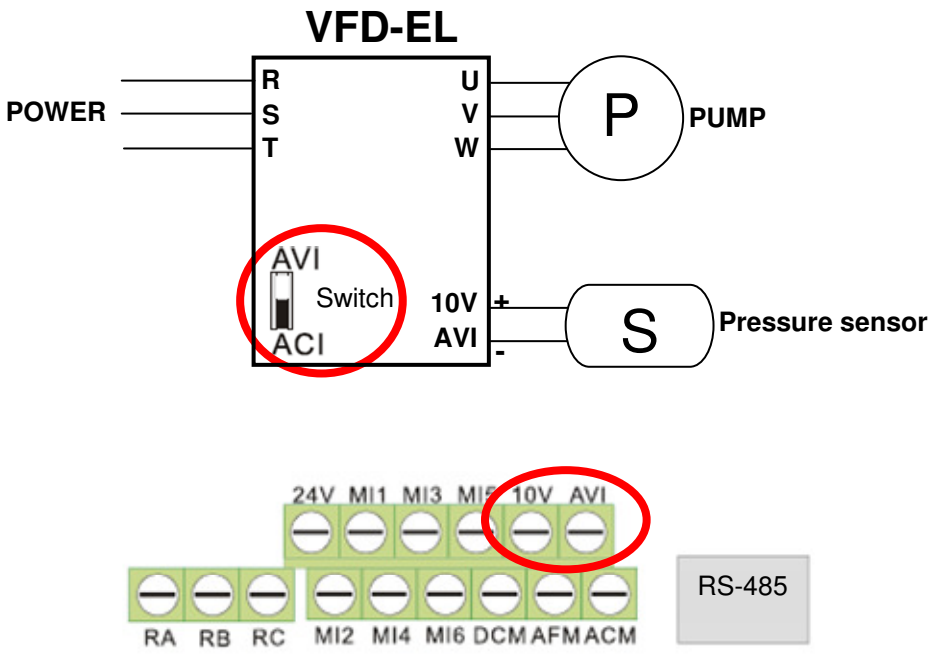
1. VFD-EL has a built-in advanced and intelligent PID controller, so a special external PID controller for constant pressure control is not needed, which saves costs.
2. VFD-EL has built-in functions for automatic detection of water supply suspension and automatic restart, so it will save the cost of a PLC with relays, which are otherwise used for realizing the same function.
3. VFD-EL is available in a full range of voltage, including 115V, 230V and 460V models. The 115V models are 1-phase; the 230V models are 1-phase/3-phase; 460V models are 3-phase. So Delta VFD-EL series AC Motor Drive can meet the various requirements of different pumps worldwide.



1.2 Wiring the pressure sensor

The principle for constant pressure water supply control is:

1. The pressure sensor feeds back a 4~20mA signal to the VFD-EL AC Motor Drive.
2. The VFD-EL AC Motor Drive outputs a frequency calculated by PID controller to control the pump speed, so the pressure set-point will be reached.



Wiring

NOTE The pressure sensor is usually a 2-wire type and outputs a 4~20mA signal.

NOTE The sensor + terminal should be connected to VFD-EL 10V terminal. The sensor – terminal should be connected to VFD-EL AVI terminal

NOTE The AVI/ACI switch should be set to ACI (factory setting is AVI).

2 PARAMETER SETTINGS

2.1 Set-point and feedback

In the following parameters the source for PID set-point and feedback and the type of feedback can be set.

Parameter	Explanation	Settings	Factory Setting
02.00	Source of First Master Frequency Command	0 UP/DOWN 1 0~+10V (AVI) 2 4~20mA (ACI) 3 RS-485 4 Keypad potmeter	0
10.00	PID Set-point Selection	0 Disable 1 Keypad 2 0~+10V (AVI) 3 4~20mA (ACI) 4 Pr10-11	0
10.01	Input Terminal for PID Feedback	0 Positive feedback from AVI 1 Negative feedback from AVI 2 Positive feedback from ACI 3 Negative feedback from ACI	0

NOTE The selection in Pr10.00 must not conflict with Pr02.00.

NOTE When Pr10.01=1, the actual PID set-point depends on Pr02.00=0 or 4.

2.2 Set pressure range

Generally, users will expect that the pressure can be set and displayed directly by the AC Motor Drive. This is possible on Delta's VFD-EL series AC Motor Drive.

Parameter	Explanation	Settings	Factory Setting
00.13	User-defined Value 1 (correspond to max.frequency)	0~9999	0
00.14	Position of Decimal Point of User-defined Value 1	0: 8888. 1: 888.8 2: 88.88 3: 8.888	0

The maximum pressure can be set in Pr00.13 (User-defined Value 1) and the position of the decimal point in Pr00.14.

Example:

For a pressure setting range of 0.0~10.0bar, set Pr00.13 to 100 and Pr00.14 to 1.
For a pressure setting range of 0.00~10.00bar, set Pr00.13 to 1000 and Pr00.14 to 2.

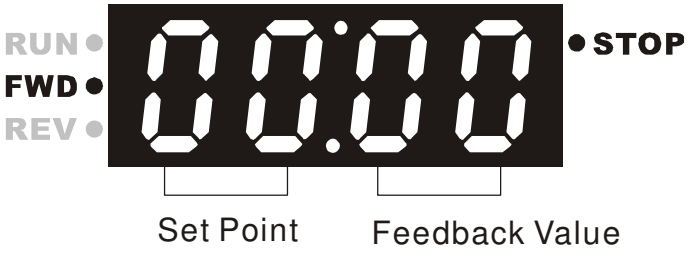
2.3 Set display content

Usually, users will expect that the target and current pressure can be displayed directly by AC Motor Drive. Delta's VFD-EL series AC Motor Drive can do it.

Parameter	Explanation	Settings	Factory Setting
10.18	PID Control Detection Signal Reference	1.0~99.9	99.9
00.03	✓ Start-up Display Selection	0~5 * 3: Display user-defined unit (acc. to Pr00.04)	0
00.04	✓ Content of Multi-function Display	0~11 * 8: Display PID setting and feedback signal	0

* Refer to the user manual.

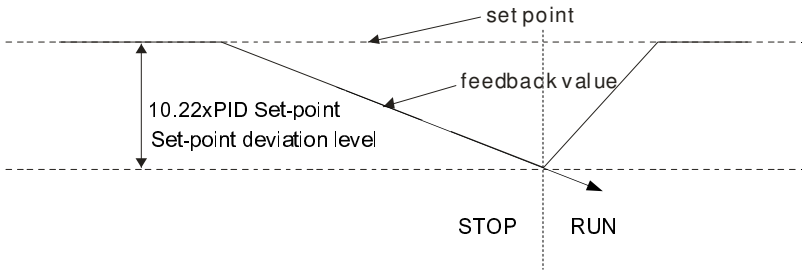
Set the maximum feedback pressure in Pr10.18.
To display the set-point and actual feedback pressure (also at power on); set Pr00.03 to 3 and Pr00.04 to 8. If you want another display at power on, set Pr00.03≠3. By pressing MODE several times, you can also display set-point and feedback.



2.4 Set deviation range (constant pressure status)

Parameter	Explanation	Settings	Factory Setting
10.22	✓ Set Point Deviation Level	0~100%	0
10.23	Detection Time of Set Point Deviation Level	1~9999sec	10

When the deviation between set-point and feedback is less than Pr10.22 (deviation in the range between [PID set-point] and [PID set-point] - [Pr10.22×PID set-point]) for a time exceeding the setting of Pr10.23, the VFD-EL will decelerate (by Pr01.12 setting) to stop and is in the constant pressure status. The system will be ready when the deviation is within the range of [PID set-point] ± [Pr10.22×PID set-point] during deceleration.

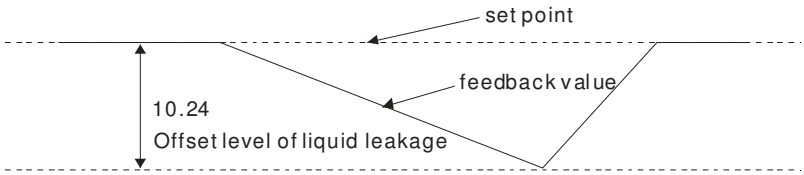


2.5 Set liquid leakage detection function

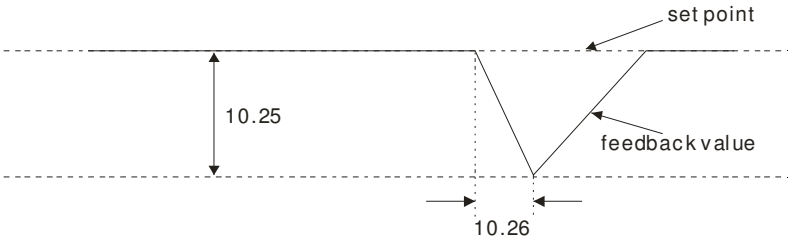
When VFD-EL is in constant pressure status, see 2.4, it can detect liquid leakage in the system. When liquid leaks (the feedback pressure drops slowly), the VFD-EL water supply (PID) controller can be set not to respond to it in order to prevent frequent run/stop actions. With the following parameters the liquid leakage detection can be set.

Parameter	Explanation	Settings	Factory Setting
10.24	↗ Offset Level of Liquid Leakage	0~50%	0
10.25	↗ Liquid Leakage Change Detection	0: disable 0~100%	0
10.26	↗ Time Setting for Liquid Leakage Change	0: disable 0.1~10.0sec	0.5

In the constant pressure status, when the liquid leakage is higher than [Pr10.24×PID set-point]; so the feedback is less than [PID set-point] – [Pr10.24xPID set-point]; VFD-EL will start to run. It is used to prevent frequent start/stop operation due to liquid leakage.



When the rate of change of feedback value is higher than [Pr10.25/Pr10.26], it is assumed the leakage is too fast or there's more than just liquid leakage. When the system is in constant pressure status, the VFD-EL will start to run if this is the case.



2.6 Set water supply suspension detection function

If the water pressure falls below the level set in Pr10.12 for the duration of Pr10.13, either the pressure is really too low, the sensor is defect or its connection is broken, it can cause damage to the pump or system.

Parameter	Explanation	Settings	Factory Setting
10.12	Erroneous PID feedback level	1.0~50.0%	10.0
10.13	Detection time of erroneous PID feedback level	0.1~300.0sec	5.0
03.00	Multi-function relay	0~22 * 16: PID supervision	8
10.20	Treatment of the Erroneous PID Feedback Level	0: Keep operating 1: Coast to stop 2: Ramp to stop 3: Ramp to stop and restart after time set in Pr10.21	0
10.21	Restart Delay Time after Erroneous PID Deviation Level	1~9999 sec	60

* Refer to the user manual.

When the offset, the difference between set-point and feedback, is higher than [Pr10.12xPr01.00] for a duration of Pr10.13 seconds, VFD-EL will act acc. to Pr10.20. Also an output signal can be set in Pr03.00. After a delay of Pr10.21 seconds, it will run again. This cycle will continue until the water pressure is restored or the sensor and its connection are repaired.

NOTE For more information about parameters and setting, please refer to the user manual.

3 PARAMETER SETTING EXAMPLE

3.1 System and requirements

VFD-EL controls a 50Hz pump to keep the pressure at 6bar (so the set-point is 6bar).
The maximum frequency is 50Hz.
The set-point range is 0-10bar. Set-point via keypad UP/DOWN keys with 2 decimals, so from 0.00~10.00bar.
The feedback sensor is 0-20bar=4-20mA.
The constant pressure status range is 0.6bar (10%).
When due to leakage the pressure becomes lower than 5bar, the AC Motor Drive has to start running again.
When due to leakage the pressure changes more than 0.24bar in 2s, the AC Motor Drive has to start running again.
When the pressure drops 5bar below set-point, the AC Motor Drive has to ramp to stop and retry after 15s.

3.2 Parameters

Parameter	Setting	Explanation
00.03	3	Start-up display is the content of user-defined unit.
00.04	8	User-defined: Simultaneous display of PID set-point and feedback signal.
00.13	1000	It is used to set the position of decimal point of Pr00.13 (user-defined value 1 which corresponds to max. frequency). Set Pr00.13 to 1000 and Pr00.14 to 2, 10.00 will be displayed.
00.14	2	
01.00	50Hz	Set according to pump specifications.
01.01	50Hz	
01.02	230V or 400V	
01.09	0.5s	Acceleration Time 1, adjust according to system requirement. Set as short as possible without OC. **
01.10	5.0s	Deceleration Time 1, adjust according to system requirement. Set as short as possible without OV. **
01.12	3.0s	Deceleration Time 2 When the pressure reaches the set point (deviation <Pr10.22 for Pr10.23 time), the AC Motor Drive will decelerate to stop and this deceleration time is the setting of Pr01.12. Do not set shorter than Pr01.10! See also Pr10.22 and Pr10.23.
02.00	0	Frequency source command is digital keypad UP/DOWN.
02.01	0	Operation command by digital keypad RUN/STOP keys.
10.00	1	PID set point is set by the digital keypad (set Pr02.00=0 or 4).
10.01	3	Negative PID feedback from external terminal ACI (4~20mA).
10.02	1.2	Adjust according to application requirement.
10.03	0.7s	
10.04	0s	
10.10	2.0	Because the feedback pressure sensor is 0~20bar but used in the 0~10bar range, the gain must be 20/10=2.0.
10.12	50.0%	When the pressure feedback value is less than 1bar (absolute value |6bar-10bar*50%|) for longer than 15s, the AC Motor Drive will act according to Pr10.20.
10.13	15.0s	
10.18	10.0	PID control detection signal reference is set to 10bar. For display purpose only.
10.19	1	Parallel PID calculation mode is suitable for constant pressure water supply control.
10.20	3	Due to water supply suspension or in case of an abnormal feedback value, the pump will ramp to stop and restart after 1800sec=30min. This action is repeated until the feedback value is normal again.
10.21	1800s	
10.22	10%	Constant pressure control parameters When the deviation (difference between feedback value and set point) exceeds 5% of the set-point, in this case 6bar*10%=0.60bar, or when the feedback value is >2.4bar for longer than 10s, the AC Motor Drive will decelerate to stop with the deceleration time acc. to Pr01.12. When the feedback value becomes <2.4bar again, the AC Motor Drive will start to run.
10.23	10s	

Parameter	Setting	Explanation
10.24	20%	Liquid leakage control parameters When the AC Motor Drive is in constant pressure status and the feedback changes less than 6bar*4%=0.24bar in 2 seconds, the AC Motor Drive will not run until the feedback value becomes lower than 6bar-20%*6bar=5bar. When the AC Motor Drive is in constant pressure status and the feedback changes more than 6bar*4%=0.24bar in 2 seconds, the AC Motor Drive will start to run, also if the level of 5bar is reached or not.
10.25	4%	
10.26	2s	

* Refer to the user manual.

** Acc and Dec times should be set as short as possible in PID applications because they will act as an extra delay (time constant) in the transfer function.