

Application Note

VFD Intelligent Pump Control

Multi-Pump Multi-Master Mode

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1 Introduction

Delta Electronics provides the IPC Intelligent Pump Control for multi-pump, multi-master systems. The advantage over other multi-pump control methods is redundancy of the master.

In traditional multi-pump systems, there is only one master. Any failure in the master will lead to complete failure of the entire pump system.

If the master fails in the IPC system, one of the slaves will assume the master role. The system keeps operating with one pump less than before. That is a big advantage in mission-critical systems, like cooling water supply for machines or installations, which are not quick and easy to shut down.

The IPC functionality comes as PLC program in the CFP2000, CP2000, MP300 and MPD300 drives. After activating the PLC, the IPC function becomes available, and the user can parametrise it just as easily. This document describes the procedures and ways of functioning.

Be aware that this document addresses qualified persons, and it cannot replace profound technical education and training.

2 Functional Description

IPC provides two basic modes of operation, quantitative and equal frequency.

It allows timed change of the master pump to level differences in runtime.

The user can select starting priority either according to pump number or to lowest runtime for best fit to the maintenance scheme.

IPC mode ensures redundancy. If the master drive is OFF or communication between the master drive and the slave drives fails, the first slave drive assumes the role of master drive. The system restarts automatically and provides the demand as good as possible with one pump less.
The priority of slave drives follows the priority setting. If the selection is ‘priority by pump sequence’ drive 2 is slave drive 1 and the first to assume the master drive role in case of failure. In ‘priority by runtime’, the drive with the second lowest runtime is slave drive 1 and will assume the master role in case of the master pump’s failure.

2.1 Quantitative Mode

Quantitative mode is a cascading PID operation mode. The master drive uses its PID controller to adjust the pump speed to meet the demand. If it runs at high speed for a certain amount of time, it will add a slave pump. The master pump will then run at full speed and adjust the slave’s speed to meet the demand. The process repeats with all available slave pumps until meeting the demand.

When the demand decreases, the process will go backwards, i.e. the master drive will remove slave drives until there is no surplus anymore to save energy.

2.2 Equal Frequency Mode

This mode is helpful, when there are no check valves in the system. Such valves avoid reflow of liquid. The disadvantages of check valves are increased cost and system complexity as well as losses in the system.

In quantitative mode without check valves, some liquid would circulate from the active pump’s outlet through the stopped pumps back to the active pump’s inlet. A reduced amount of the liquid would reach its destination and the overall efficiency would be low.

In equal frequency mode, all pumps are running, so that reflow cannot happen. Each pump uses its own PID control, so all drives run at similar, but not exactly the same frequency in spite of the mode’s name.

2.3 No Cycle

The ‘no cycle’ setting keeps the master drive fixed. There is no change of master or slave drives as long as the master drive operates correctly.

Runtime differences are likely to increase over time. Therefore, this mode is preferable for maintenance on demand schemes. Each pump and drive operates to the maximum of its lifetime. When it fails, the other pumps can keep running during repair or replacement of the failed device. There is no complete system downtime, only performance reduction during a limited amount of time.

2.4 Fixed Cycle

With ‘fixed cycle’ setting, the master drive changes after a specific time according to the pump priority. The slave drive follow suit.

This helps to level runtime differences, and is better suited to preventive maintenance schemes. Such schemes try to avoid unplanned downtime by replacing devices with a safety margin before the designated end of their lifetime. At the same time, they strive to produce as few planned stops as possible.

When all pumps have nearly the same runtime, the user can schedule maintenance for all of them at the same time. That creates a single downtime occurrence per system instead of separate ones for each pump. It requires a complete system stop for a limited time, while avoiding reduced performance at all other times.

2.5 Priority by Pump Sequence

At start, the master pump will be pump 1. First slave pump is pump 2, second is pump 3, etc.

With ‘no cycle’ setting, this priority selection will lead to the largest runtime differences, supporting maintenance on demand.

In ‘fixed cycle’, the pumps will change by one after each cycle. In the second cycle pump 2 becomes the master pump, pump 3 the first slave pump and so on. In the third cycle, pump 3 becomes the master pump, and so on. When the last pump is master pump, the next cycle will make pump 1 the master pump again. This combination levels runtime differences less effectively. They will not become 0, but will be much smaller than set to ‘no cycle’.

2.6 Priority by Runtime

At start, the pump with the lowest runtime becomes master pump. The one with the second lowest runtime becomes slave pump 1, etc.

With ‘no cycle’ setting, the pump allocation remains fixed until the next start. Runtime differences will level out slowly, while reducing the amount of switching between pumps.

In ‘fixed cycle’, the pump roles will change by one after each cycle. In the second cycle the pump with the second lowest runtime becomes the master pump, the one with the third lowest runtime becomes the first slave pump and so on. In the third cycle, the pump with the lowest runtime becomes the master pump again, and so on. This combination levels out runtime differences most effectively. It is the best fit for preventive maintenance schemes. It produces the highest amount of pump switching, which increases tear and wear slightly.

3 Wiring

3.1 Main Circuit

IPC in CFP2000 and CP2000 supports up to four pumps. In MP300 and MPD300 it supports up to eight. The pumps need to be of the same model and size for optimal control performance.

The main circuit wiring corresponds to the wiring of individual pump and drive sets. Follow the instructions in the corresponding drive manual.



Figure 3.1.1: Main Circuit Layout Principle

3.2 Communication Wiring

C2000 series drives communicate with each other through RS-485 serial communication on channel 2. The RJ-45 ports of channel 2 allow the use of off-the-shelf patch cables. That makes wiring easy and reduces the risk of wiring errors. SG+, SG- and SGGND terminals allow the use of channel 2 with self-confectioned wiring, if desired.

MP300 series drives do not provide RJ-45 ports for serial communication, but two sets of terminals. SG1+ and SG1- handle the drive-to-drive communication.



Figure 3.2.1: Communication Layout Principle

The master drive is also the Modbus master in this setup. Modbus networks can only use one master. Therefore,

- MP300 and MPD300 provide SG2+ and SG2- terminals for programming, parametrisation and communication with upper level controllers
- In C2000 series, channel 1 is available for programming and parametrisation on the RJ-45 port behind the keypad. The communication settings are fixed to 19200, 8, N, 2, RTU.
  Communication with upper level controllers requires an additional communication card

3.3 Control Wiring

In order to function as master, each drive needs command and feedback signals. If they come from the terminals, connect voltage-based signals in parallel and current based signals in series.

Most sensors with analog current output can only drive 20 mA into ≤ 500 Ω, which means one sensor can only feed two analog drive inputs in series. Likewise, sensors with analog voltage outputs often need a resistance of ≥ 10 kΩ, again limited to feed only two drives in parallel.

Table 3.3.1: Analog Input Impedances and Digital Input Currents

	CFP2000 **CP2000**	**MP300** **MPD300**
Digital Input Current	6.5 mA	3.3 mA
Current Mode Analog Input Impedance	250 Ω	
Voltage Mode Analog Input Impedance	20 kΩ	

Due to the common ACM terminal, it may not be feasible to connect the analog inputs of several drives in series, if more than one analog signal is in use on a drive.

In the case of analog current signals, the workaround is to route the current through a resistor, set the analog inputs of the drives to voltage measurement and use the voltage drop across the resistor as signal. The total resistance of that resistor and the parallel-connected drive inputs should be 500 Ω, so that 20 mA correspond to 10 V.

Table 3.3.2 lists the parallel resistor. The values in brackets state the E series, in which the closest resistor values are available.

Table 3.3.2: Parallel Resistor to Convert 20 mA to 10 V

	CFP2000 CP2000	MP300 MPD300
2 Analog Drive Inputs in Parallel	526 Ω (n/a) 523 Ω (E96) 511 Ω (E48)	
3 Analog Drive Inputs in Parallel	541 Ω (n/a) 542 Ω (E192) 536 Ω (E48)	
4 Analog Drive Inputs in Parallel	556 Ω (E192) 560 Ω (E12)	
5 Analog Drive Inputs in Parallel	-	571 Ω (n/a) 569 Ω (E192) 576 Ω (E96) 560 Ω (E12)
6 Analog Drive Inputs in Parallel	-	588 Ω (n/a) 590 Ω (E48)
7 Analog Drive Inputs in Parallel	-	606 Ω (n/a) 604 Ω (E96) 590 Ω (E48)
8 Analog Drive Inputs in Parallel	-	625 Ω (n/a) 626 Ω (E192) 620 Ω (E24)

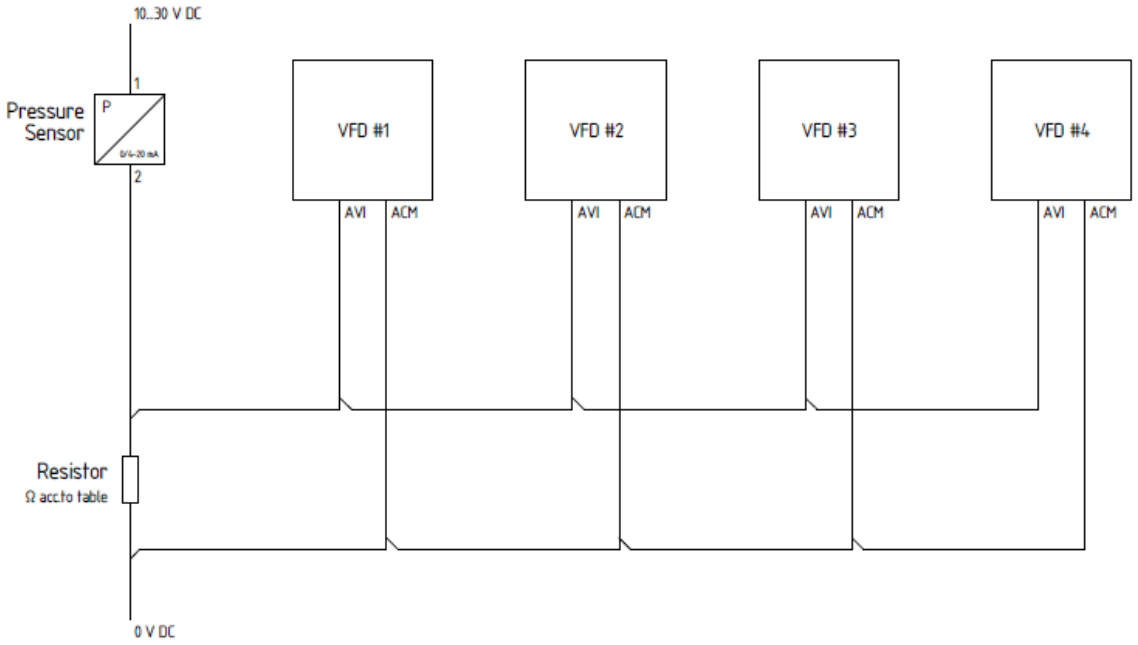


Figure 3.3.1: Wiring Diagram for Parallel Resistor to Convert 20 mA to ~10 V

In the case of a voltage signal, there is the option to add a series resistor to the parallel analog inputs. The drawback is that the voltage drop across the series resistor requires scaling of the analog inputs and reduces the sensing resolution. E.g., four analog inputs of C2000 series drives will have a total resistance of 5 kΩ. Adding another 5 kΩ in series leads to a maximum voltage of 5 V at the analog input. The resolution of the measurement will go down from 1/10000 to 1/5000 of the sensing range.

Table 3.3.3 lists the series resistors. The values in brackets state the E series, in which the closest resistor values are available. 2|| indicates two resistors in parallel configuration, 2& two resistors in series configuration

Table 3.3.3: Series Resistor for Parallel Analog Inputs at ~50% resolution

	CFP2000 CP2000	MP300 MPD300
2 Analog Drive Inputs in Parallel	10 kΩ (E12)	
3 Analog Drive Inputs in Parallel	6.67 kΩ (n/a) 6.65 kΩ (E96) 6.8 kΩ (E12)	
4 Analog Drive Inputs in Parallel	5 kΩ (n/a) 2|| 10 kΩ (E12) 4.99 kΩ (E96) 5.1 kΩ (E24)	
5 Analog Drive Inputs in Parallel	-	4 kΩ (n/a) 2& 2 kΩ (E24) 4.02 kΩ (E48) 3.9 kΩ (E12)
6 Analog Drive Inputs in Parallel	-	3.33 kΩ (n/a) 3.32 kΩ (E48) 3.3 kΩ (E6)
7 Analog Drive Inputs in Parallel	-	2.86 kΩ (n/a) 2.87 kΩ (E48) 3.0 kΩ (E24)
8 Analog Drive Inputs in Parallel	-	2.5 kΩ (n/a) 2.49 kΩ (E48) 2.4 kΩ (E24)

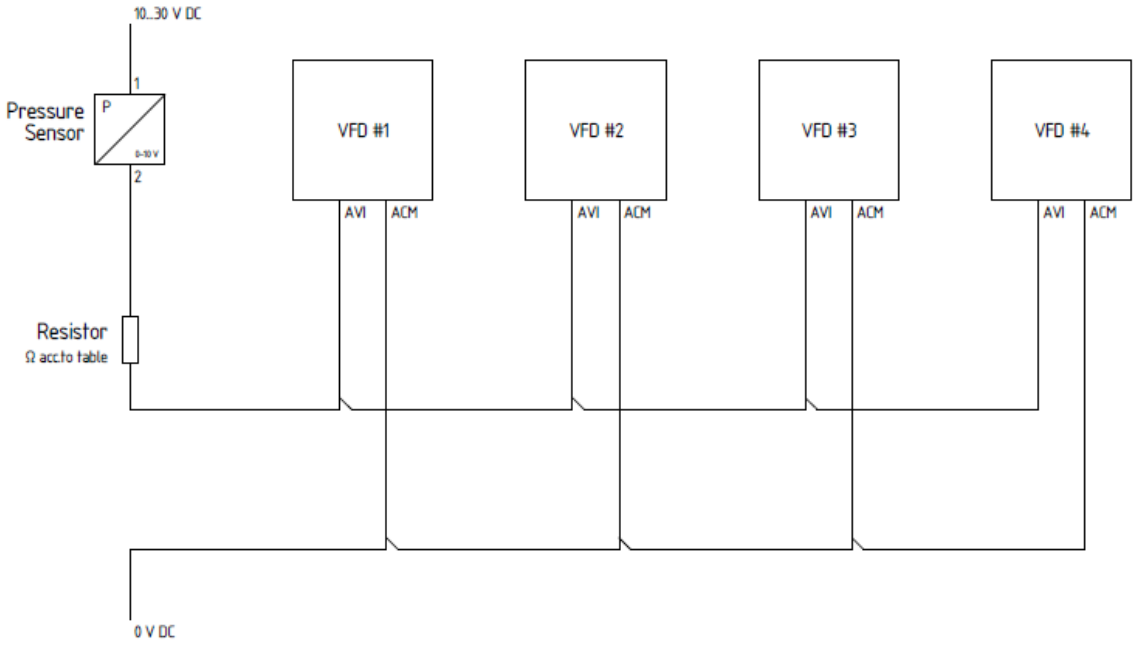


Figure 3.3.1: Wiring Diagram for Resistor in Series to Parallel Analog Inputs

4 Parameter Settings

4.1 CFP2000 and CP2000

4.1.1 Software

Activate the drive's built-in PLC on all drives to enable the IPC function.
To do that, press MENU → select PLC Function with the up and down arrow keys → press ENTER → Select PLC Run with the up and down arrow keys → press ENTER

If the IPC function is not available, check if the corresponding PLC program is present. In case the program is missing, contact Delta and we will provide it free of charge.

Use a USB-A to RJ-45 Modbus converter to connect the drive to a PC, e.g. Delta IFD6500 or Delta IFD6530.

Download the latest version of the following software to connect to the internal PLC. Any of the three packages will do.

From the DIAStudio Homepage:

- DIAStudio
  A software suite for many Delta products. After installation use DIADesigner for PLC commissioning

From the Download Center:

- ISPSoft & COMMGR
  ISPSoft is a PLC programming software. COMMGR provides the communication drivers needed to communicate between PLC and drive

- WPLSoft
  WPLSoft is a PLC programming software with integrated communication driver settings

Parameter settings are possible through the keypad of the drive. We also provide software solutions, which are more comfortable, enable parameter backup and restore as well as oscilloscope functionalities for drive commissioning and diagnostics. Download the latest versions of any of the below packages and use them with the aforementioned converters Delta IFD6500 or Delta IFD6530.

From the DIAStudio Homepage:

- DIAStudio
  A software suite for many Delta products. After installation use DIADesigner for drive commissioning

From the Download Center:

- VFDExplorer Lite
  A software with focus on diagnostics. High resolution oscilloscope and on the fly parameter modification

- VFDSoft
  An easy-to-use software with focus on parameter management. Oscilloscope with standard resolution. Modbus diagnostic and test tool

4.1.2 Parameter List

The following list contains only parameters related to the IPC function. The drive's user manual provides information on further parameters.

Table 4.1.2.1: CFP200 & CP2000 IPC Parameter List

Par.	Name	Settings	Default
00-21	Operation command source (AUTO)	0: Digital keypad 1: External terminals	0
00-25	User-defined characteristics	bit 0–3: user-defined decimal places 0000h-0000b: no decimal place 0001h-0001b: one decimal place 0002h-0010b: two decimal places 0003h-0011b: three decimal places bit 4–15: user-defined unit 000xh: Hz 001xh: rpm 002xh: % 003xh: kg/cm2 004xh: m/s 005xh: kW 006xh: HP 007xh: ppm 008xh: 1/m 009xh: kg/s 00Axh: kg/m 00Bxh: kg/h 00Cxh: lb/s	0

		00Dxh: lb/m 00Exh: lb/h 00Fxh: ft/s 010xh: ft/m 011xh: m 012xh: ft 013xh: degC 014xh: degF 015xh: mbar 016xh: bar 017xh: Pa 018xh: kPa 019xh: mWG 01Axh: inWG 01Bxh: ftWG 01Cxh: psi 01Dxh: atm 01Exh: L/s 01Fxh: L/m 020xh: L/h 021xh: m3/s 022xh: m3/h 023xh: GPM 024xh: CFM xxxxh: Hz	
00-26	Maximum user-defined value	0: No function 0–65535 (when Pr.00-25 is set to no decimal place) 0.0–6553.5 (when Pr.00-25 is set to one decimal place) 0.00–655.35 (when Pr.00-25 is set to two decimal places) 0.000–65.535 (when Pr.00-25 is set to three decimal places)	0
04-50	Mode selection	Bit 0,1,2: 000: General-purpose Inverter 010: Multi-master station	0

		100: Single master station Bit 3: 0: According to the motor running time 1: According to the drive station number Bit 4: 0: Quantitative control 1: equal frequency Bit 5: 0: N/A 1: Timing cycle control Bit 6: Communication failure processing, with at least two pumps in the system. 0: Switch to slave mode and stop running 1: Switch to slave mode to continue running. Bit 7: Sleep mode 0: Off 1: On	
04-51	Target	0-65535	0
04-52	Feedback	0-65535	Read only
04-53	Sensor range	0-65535	5000
04-54	Cycle time	0-65535 [min]	30
04-55	PID dead band	0-65535	3
04-56	Proportional gain (P)	0-65535 [0.01]	20
04-57	Integral time (I)	0-65535 [0.01 s]	2
04-58	Differential time (D)	0-65535 [0.01 s]	0
04-59	Pump add delay	0-65535 [0.1 s]	100
04-60	Pump remove delay	0-65535 [0.1 s]	100
04-61	Pump add frequency	0-65535 [0.01 Hz]	5000
04-62	Pump remove	0-65535 [0.01 Hz]	0

	frequency		
04-63	High pressure alarm threshold	0-Sensor range	5000
04-64	Low pressure alarm threshold	0-Sensor range	0
04-65	Pressure alarm delay	0-65535 [0.1 s]	100
04-66	Sleep frequency	0-65535 [0.01 Hz]	0
04-67	Wake frequency	0-65535 [0.01 Hz]	0
04-68	Sleep/wake delay	0-65535 [0.1 s]	100
04-69	Acceleration time	0-65535 [0.01 s]	100
04-70	Deceleration time	0-65535 [0.01 s]	100
04-71	Motor running hours	0-65535 [h]	Read only
04-72	Maximum Master Change Count	0-65535	3
04-73	Analog source	0: AVI1 1: ACI 2: AVI2 3: AVI10 4: AVI11	0
04-74	Disable high and low press alarm	0: Enable low and high pressure alarm 1: Disable low, enable high pressure alarm 2: Enable low, disable high pressure alarm 3: Disable low and high pressure alarm	0
04-75	Reserved		Read only
04-76	Reserved		Read only
04-77	Reserved		Read only

04-78	Reset	11: Clear motor running hours 99: Reset to default	0
04-79	Error code		Read only
04-80	PLC program version		Read only
09-00	Communication address	1-254	1
09-01	COM1 transmission speed	4.8–115.2 Kbps	9.6
09-02	COM1 transmission fault treatment	0: Warn and continue operation 1: Fault and ramp to stop 2: Fault and coast to stop 3: No warning, no fault and continue operation	3
09-03	COM1 time-out detection	10.0–100.0 sec.	0.0
09-04	COM1 communication protocol	1: 7, N, 2 (ASCII) 2: 7, E, 1 (ASCII) 3: 7, O, 1 (ASCII) 4: 7, E, 2 (ASCII) 5: 7, O, 2 (ASCII) 6: 8, N, 1 (ASCII) 7: 8, N, 2 (ASCII) 8: 8, E, 1 (ASCII) 9: 8, O, 1 (ASCII) 10: 8, E, 2 (ASCII) 11: 8, O, 2 (ASCII) 12: 8, N, 1 (RTU) 13: 8, N, 2 (RTU) 14: 8, E, 1 (RTU) 15: 8, O, 1 (RTU) 16: 8, E, 2 (RTU) 17: 8, O, 2 (RTU)	1
09-35	PLC address	1-254	2

4.1.3 Parameter Description

The following descriptions relate only to the IPC function. The drive's user manual provides information on further parameters.

00-21 Operation Command (AUTO) Source

Default: 0

Settings: 0: Digital keypad
1: External terminals

- 🕮 Determines the operation frequency source in the AUTO mode
- 🕮 In IPC mode, only digital keypad or external terminals are valid settings

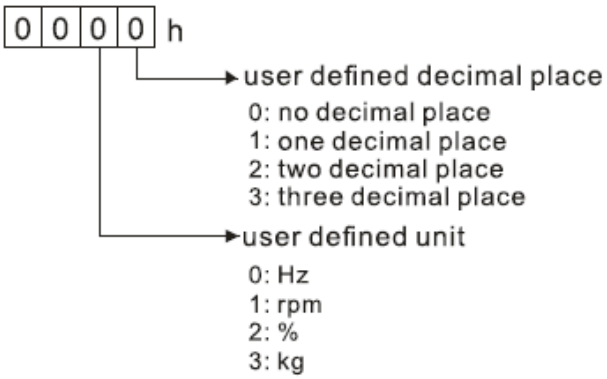
00-25 Maximum User-Defined Value

Default: 0

Settings: Bit0–3: user-defined decimal place
0000b: no decimal place
0001b: one decimal place
0010b: two decimal places
0011b: three decimal places
Bit4–15: user-defined unit
000xh: Hz
001xh: rpm
002xh: %
003xh: kg
004xh: m/s
005xh: kW
006xh: HP
007xh: ppm
008xh: 1/m
009xh: kg/s
00Axh: kg/m
00Bxh: kg/h
00Cxh: lb/s
00Dxh: lb/m
00Exh: lb/h
00Fxh: ft/s
010xh: ft/m

011xh: m
012xh: ft
013xh: degC
014xh: degF
015xh: mbar
016xh: bar
017xh: Pa
019xh: mWG
01Axh: inWG
01Bxh: ftWG
01Cxh: psi
01Cxh: psi
01Dxh: atm
01Exh: L/s
01Fxh: L/m
020xh: L/h
021xh: m3/s
022xh: m3/h
023xh: GPM
024xh: CFM
xxxxh: Hz

- Bit0–3: the displayed units for the control frequency F page and user-defined (Pr.00-04 = d10 PID feedback) and the displayed number of decimal places for Pr.00-26 (supports up to three decimal places)
- Bit4–15: the displayed units for the control frequency F page, user-defined (Pr.00-04 = d10, PID feedback) and Pr.00-26



- You must convert the setting value to decimal when using the keypad to set parameters.

  Example: Assume that the user-defined unit is inWG and user-defined decimal

place is the third decimal point. According to the information above, the corresponding unit to inWG is 01Axh (x is the set decimal point), and the corresponding unit to the third decimal place is 0003h, then inWG and the third decimal point displayed in hexadecimal is 01A3h, that is 419 in decimal value. Thus, set Pr.00-25 = 419 to complete the setting

00-26 Maximum User-Defined Value

Default: 0

Settings: 0: Disable
0–65535 (when Pr.00-25 is set to no decimal place)
0.0–6553.5 (when Pr.00-25 is set to one decimal place)
0.00–655.35 (when Pr.00-25 is set to two decimal places)
0.000–65.535 (when Pr.00-25 is set to three decimal places)

📖 When Pr.00-26 is NOT set to 0, the user-defined value is enabled. After selecting the displayed unit and number of decimal places with Pr.00-25, the setting value of Pr.00-26 corresponds to Pr.01-00 (drive's maximum operating frequency).
Example: When the frequency set in Pr.01-00 = 60.00 Hz, the maximum user-defined value for Pr.00-26 is 100.0%. This also means that Pr.00-25 is set as 0021h.

✎ NOTE Set Pr.00-25 before using Pr.00-26. After you finish setting, when Pr.00-26 is not 0, the displayed unit on the keypad shows correctly according to Pr.00-25 settings.

04-50 IPC Mode

Default: 0

Settings: Bit 0-2 Multi-pump Mode
000 General purpose
010: Multi-master
100: Single master
Bit 3 Priority
0 Priority by runtime
1 Priority by sequence
Bit 4 Pump control

0 Quantitative control
1 Equal frequency control
Bit 5 Fixed time mode
0 No cycle
1 Fixed cycle
Bit 6 Communication error processing
0 Switch to slave and stop
1 Switch to slave and keep running
Bit 7 Sleep mode
0 Off
1 On

🕮 Bit 0, 1, 2

000: multi-pump mode disable

010: multi-master mode enable. If the master is OFF or communication error occurs, the next slave assumes the master role

100: single-master mode enable. If the master is OFF or communication error occurs, all pumps are OFF

🕮 Bit 3

0: priority by runtime. The pump starting sequence depends on the accumulated runtime of each pump. The lower the runtime, the higher the starting priorityPr.00-26 is NOT set to 0, the user-defined value is enabled.

🕮 Bit 4

0: quantitative control. Pumps operate in cascading manner. The higher the demand, the more pumps operate

1: equal frequency control. All pumps run together at similar speed

🕮 Bit 5

0: no cycle. Active pump keeps running

1: time cycle. After a fixed cycle, the master pump changes and the slave pumps follow suit. This mode reduces runtime differences

🕮 Bit 6

0: on communication error, stop

1: on communication error, change to next available slave pump and keep working

🕮 Bit 7

0: sleep mode off. The pumps run until the demand is 0 and restart as soon as the demand is above 0

1: sleep mode on. The pumps stop, when the demand falls below the sleep

frequency in Pr.04-66 for more than the sleep/wake delay in Pr.04-68. They restart, when the demand rises above the wake frequency in Pr. 04-67 for more than the sleep/wake delay in Pr.04-68

04-51 Multi-Pump PID Set Point

Default: 0

Settings: 0-Pr.04-53

🕮 Command value

🕮 Pr.00-25 & Pr.00-26 determine the physical unit or Pr.04-51

04-52 Multi-Pump PID Present Value

Default:
Read Only

Settings: 0-Pr.04-53

🕮 Feedback value

🕮 Pr.00-25 & Pr.00-26 determine the physical unit or Pr.04-52

04-53 Multi-Pump PID Sensor Range

Default:
5000

Settings: 0-max speed [0.01 Hz] according to Pr.01-00

🕮 Pr.01-00 corresponds to the maximum value of physical unit.
Example: Pr.01-00 = 50.00 Hz, Pr.00-25 & Pr.00-26 = 10 bar → Pr.04-53 = 5000 means 10 bar

04-54 Multi-Pump Cycle Time

Default: 30

Settings: 0-32767 [min]

🕮 If Pr.04-50 bit 5 = 1, the master pump changes to the next available slave pump after running for the time in Pr.4-54, etc.
Slave pump priority depends on Pr.04-50 bit 3

04-55 PID Dead Band

Default: 3

Settings: 0-32767 [0.01 Hz]

📖 As long as the difference between set point and present value is smaller than this value, the PID control will pause and maintain the output stable

04-56 PID Proportional Gain

Default: 20

Settings: 0-32767 [0.01]

📖 Proportional gain of PID control. A value of 100 means the gain is 1.
That is the case, if the pump running at maximum speed, achieves exactly the maximum sensor range.
If the pump achieves half the sensor range, the gain should be 2.
The sensor is reasonable, when the pump achieves 70-90% of the sensor range. There should at least be 10% margin for good control performance. More than 30% margin means, the sensor will not operate in its best precision range

04-57 PID Integral Time

Default: 2

Settings: 0-32767 [0.01 s]

📖 This defines the time the integrator needs to achieve the same output action as the proportional gain after a step of the feedback value, if each of them did work alone.
If the feedback overshoots and/or oscillates, increase Pr.04-57. If the feedback rises very slowly and/or never reaches the set point, decrease Pr.04-57

04-58 PID Derivative Time

Default: 0

Settings: 0-32767 [0.01 s]

📖 This defines the time the differentiator needs to achieve the same output action as the proportional gain after a step of the feedback value, if each of them did work alone.
If the feedback overshoots only slightly, use Pr.04-58 to level the overshoot

04-59 Pump Add Delay

Default: 100

Settings: 0-32767 [0.1 s]

📖 See Pr.04-61

04-60 Pump Remove Delay

Default: 100

Settings: 0-32767 [0.1 s]

📖 See Pr. 04-62

04-61 Pump Add Frequency

Default: 5000

Settings: 0-Pr.01-00 [0.01 Hz]

📖 If Pr.04-50 bit 4 = 1 and the output frequency of the highest active pump remains at or above Pr04-61 for more than the time in Pr.04-59, the next slave pump starts

📖 If the setting of Pr.04-61 is higher than Pr.01-00, the PLC will overwrite Pr.04-61 with Pr.01-00

04-62 Pump Remove Frequency

Default: 0

Settings: 0-Pr.04-61 [0.01 Hz]

📖 If Pr.04-50 bit 4 = 1 and the output frequency of the highest active pump remains at or below Pr04-62 for more than the time in Pr.04-60, the pump stops

📖 If the setting of Pr.04-62 is higher than Pr.04-61, the PLC will overwrite Pr.04-62 with 0.00 Hz

04-63 High Pressure Alarm Threshold

Default: 5000

Settings: 0-Pr.04-53 [0.01 Hz]

📖 If Pr.04-74 = 0 or 1, if the feedback remains at or above Pr.04-63 for more than the time in Pr.04-65, the drive will stop and RLY1 will activate continuously to

indicate alarm

📖 Example: Pr.01-00 = 50.00 Hz, Pr.00-25 & Pr.00-26 = 10 bar → Pr.04-63 = 5000 means 10 bar

04-64 Low Pressure Alarm Threshold

Default: 0

Settings: 0-Pr.04-53 [0.01 Hz]

📖 If Pr.04-74 = 0 or 2, if the feedback remains at or below Pr.04-64 for more than the time in Pr.04-65, the drive will stop and RLY1 will activate continuously to indicate alarm

📖 Example: Pr.01-00 = 50.00 Hz, Pr.00-25 & Pr.00-26 = 10 bar → Pr.04-64 = 5000 means 10 bar

04-65 Pressure Alarm Delay

Default: 100

Settings: 0-32767 [0.1 s]

📖 See Pr.04-63 and Pr.04-64

04-66 Sleep Frequency

Default: 0

Settings: 0-32767 [0.01 Hz]

📖 If Pr.04-50 bit 7 = 0 and the master pump output frequency remains at or below Pr.04-66 for more than the time in Pr.04-68, the pump will stop

04-67 Wake Frequency

Default: 0

Settings: 0-32767 [0.01 Hz]

📖 If Pr.04-50 bit 7 = 0 and the master pump output frequency remains at or above Pr.04-67 for more than the time in Pr.04-68, the pump will restart

04-68 Sleep / Wake Delay

Default: 100

Settings: 0-32767 [0.1 s]

📖 See Pr.04-63 and Pr.04-64

04-69 Acceleration Time

Default: 2500

Settings: 0-32767 [0.01 s]

📖 Overrides settings of Pr.01-12, Pr.01-14, Pr.01-16 and Pr.01-18

04-70 Deceleration Time

Default: 2500

Settings: 0-32767 [0.01 s]

📖 Overrides settings of Pr.01-13, Pr.01-15, Pr.01-17 and Pr.01-19

04-71 Pump Operating Hours

Default: Read Only

Settings: 0-32767 [h]

📖 Pump operating hours counter

📖 Pr.04-78 allows reset during maintenance

04-72 Master Pump Change Limit

Default: 3

Settings: 0-32767

📖 Maximum allowed count of master pump change due to power loss or communication error

04-73 Feedback Source Selection

Default: 0

Settings: 0: AVI1
1: ACI
2: AVI2
3: AVI10

4: AVI11

📖 IPC can only use analog feedback

04-74 Pressure Alarm Setting

Default: 0

Settings: 0: Enable low and high pressure alarm
1: Disable low, enable high pressure alarm
2: Enable low, disable high pressure alarm
3: Disable low and high pressure alarm

📖 See Pr.04-63, Pr-04-64 and Pr.04-65

04-75 Reserved

Default:
Read Only

Settings:

04-76 Reserved

Default:
Read Only

Settings:

04-77 Reserved

Default:
Read Only

Settings:

04-78 Reset

Default: 0

Settings: 11: clear pump operating time
99: reset IPC parameters to factory default

04-79 Error Code

Default:
Read Only

Settings: Bit 0: high pressure alarm
Bit 1: low pressure alarm
Bit 2: master drive disconnection

04-80 IPC Program Version

Default:
Read Only

Settings: 0-32767 [0.01]

09-00 Communication Address

Default: 1

Settings: 1-254

📖 Sets the communication address of the drive for RS-485 serial communication. The communication address for each AC motor drive and PLC must be unique

📖 If Pr.04-50 bit 0-2 = 010, only the following settings are allowed
Master drive = 1
Slave drive 1 = 3
Slave drive 2 = 5
Slave drive 3 = 7

09-01 COM1 Transmission Speed

Default: 9.6

Settings: 4.8–115.2 Kbps

📖 Sets the transmission speed between the computer and the AC motor drive

📖 Options are 4.8 Kbps, 9.6 Kbps, 19.2 Kbps, 38.4 Kbps, 57.6 Kbps or 115.2 Kbps. Otherwise, the transmission speed is set to the default 9.6 Kbps

09-02 COM1 Transmission Fault Treatment

Default: 3

Settings: 0: Warn and continue operation
1: Fault and ramp to stop
2: Fault and coast to stop
3: No warning, no fault and continue operation

📖 Determines the error reaction when the host controller does not continuously transmit data to the AC motor drive during Modbus communication. The detection time is based on the Pr.09-03 setting

09-03 COM1 Time-out Detection

Default: 0

Settings: 0.0–100.0 [s]

📖 Sets the communication transmission time-out value

📖 If Pr.04-50 bit 0-2 = 010 or 100, the suggested setting is ≥ 10.0 s

09-04 COM1 Communication Protocol

Default: 1

Settings: 1: 7, N, 2 (ASCII)
2: 7, E, 1 (ASCII)
3: 7, O, 1 (ASCII)
4: 7, E, 2 (ASCII)
5: 7, O, 2 (ASCII)
6: 8, N, 1 (ASCII)
7: 8, N, 2 (ASCII)
8: 8, E, 1 (ASCII)
9: 8, O, 1 (ASCII)
10: 8, E, 2 (ASCII)
11: 8, O, 2 (ASCII)
12: 8, N, 1 (RTU)
13: 8, N, 2 (RTU)
14: 8, E, 1 (RTU)
15: 8, O, 1 (RTU)
16: 8, E, 2 (RTU)
17: 8, O, 2 (RTU)

09-35 PLC Address

Default: 2

Settings: 1–254

🕮 Sets the communication address of the drive's integrated PLC for RS-485 serial communication. The communication address for each AC motor drive and PLC must be unique

🕮 If Pr.04-50 bit 0-2 = 010, only the following settings are allowed
Master drive = 2
Slave drive 1 = 4
Slave drive 2 = 6
Slave drive 3 = 8

4.1.4 Troubleshooting

This chapter refers to IPC-related warnings and errors only. For other issues, please check the drive's user manual.

Item	Description		
Modbus timeout	Modbus transmission timeout occurs		
Action and Reset			
Action condition	When the communication time exceeds the detection time for Pr.09-03 time-out.		
Action Time	Pr.09-03		
Warn ID	5	Fault name	Communication error 10 (CE10)
Warn display	CE10		
Fault treatment	Pr.09-02 0: Warn and continue operation 3: No warning and continue operation		
Reset method	Auto reset when receiving the next communication packet.		
Reset condition	Immediately reset		
Record	Yes		

Fault ID	58	Fault name	Modbus transmission time-out (CE10)
Fault display	CE10 Pr.04-79 = 4		
Fault treatment	Pr.09-02 1: Fault and ramp to stop 2: Fault and coast to stop 3: No warning and continue operation		
Reset method	Manual reset		
Reset condition	Immediately reset		
Record	Yes		
Cause	Corrective Action		
The upper unit does not transmit the communication command within Pr.09-03 setting time	Check if the upper unit transmits the communication command within the setting time for Pr.09-03.		
Malfunction caused by interference	Verify the wiring and grounding of the communication circuit. It is recommended to separate the communication circuit from the main circuit, or cross at 90° for effective anti-interference performance.		
Different communication setting from the upper unit	Check if the setting for Pr.09-01 and Pr.09-04 are the same as the setting for the upper unit.		
Disconnection or bad connection of the cable	Check the cable and replace it if necessary.		

Item	Description		
High pressure fault	The feedback pressure is too high		
Action and Reset			
Action level	The feedback pressure is higher than the setting in Pr.04-62.		
Action Time	Pr.04-64		
Fault ID	None	Fault name	High water pressure (HPS)
Fault display	Pr.04-79 = 1		
Fault treatment	Fault and coast to stop		
Reset method	Manual reset		
Reset condition	Immediately reset		
Record	No		
Cause	Corrective Action		
The pressure sensor is broken	Replace the pressure sensor		

Item	Description		
Low pressure fault	The feedback pressure is too high		
Action and Reset			
Action condition	The feedback pressure is lower than the setting in Pr.04-63		
Action Time	Pr.04-64		
Fault ID	None	Fault name	Low water pressure (LPS)
Fault display	Pr.04-79 = 2		
Fault treatment	Fault and coast to stop		

Reset method	Manual reset
Reset condition	Immediately reset
Record	No
Cause	Corrective Action
Insufficient outlet pressure	Check for leakages. Make sure that there is sufficient supply at the pump inlet.
Feedback sensor failure	Repair or replace the sensor

4.2 MP300 and MPD300

4.2.1 Software

On all drives, set parameter 00-02 = 2 to reset all parameters to factory default. Then set parameter 00-02 = 110 to load the IPC function program into the PLCs. Activate the PLCs to enable the IPC function. To do that, push MODE repeatedly until “PLC0” shows on the screen → select PLC1 with the up and down arrow keys → push ENTER.

Use a USB/Modbus converter, e.g. Delta IFD6500 or Delta IFD6530 with an RJ-45 patch cable to connect the drives to a PC one after the other.

Download the latest version of the following software to connect to the internal PLC. Any of the three packages will do.

From the DIAStudio Homepage:

- DIAStudio
  A software suite for many Delta products. After installation use DIADesigner for PLC commissioning

From the Download Center:

- ISPSoft & COMMGR
  ISPSoft is a PLC programming software. COMMGR provides the communication drivers needed to communicate between PLC and drive

- WPLSoft
  WPLSoft is a PLC programming software with integrated communication driver settings

Parameter settings are possible through the keypad of the drive. We also provide software solutions, which are more comfortable, enable parameter backup and restore as well as oscilloscope functionalities for drive commissioning and diagnostics. Download the latest versions of any of the below packages.

From the DIAStudio Homepage:

- DIAStudio
  A software suite for many Delta products. After installation use DIADesigner for drive commissioning

From the Download Center:

- VFDExplorer Lite
  A software with focus on diagnostics. High resolution oscilloscope and on the fly parameter modification

- VFDSoft
  An easy-to-use software with focus on parameter management. Oscilloscope with standard resolution. Modbus diagnostic and test tool

4.2.2 Parameter List

The following list contains only parameters related to the IPC function. The drive's user manual provides information on further parameters.

Table 4.2.2.1:MP300 & MPD300 IPC Parameter List

Par.	Name	Settings	Default
00-02	Parameter reset	0: No function 1: Write protection for parameters 5: Return kWh displays to 0 6: Reset PLC 8: Disable keypad RUN key 10: Reset all parameters to defaults (base frequency is 150 Hz) 12: Reset all parameters to defaults with base frequency at 150 Hz (keep the user-defined parameter values Pr.13-01–Pr.13-50) 110: Load IPC function program into PLC	0
00-20	Master frequency command source (AUTO, REMOTE)	0: Digital keypad 1: RS-485 communication input (COM1) 2: External analog input (refer to Pr.03-00) 3: External UP / DOWN terminal (multi-function input terminals) 8: Communication card (does not include CANopen card)	
00-21	Operation command source (AUTO)	0: Digital keypad 1: External terminals	0
00-25	User-defined characteristics	bit 0–3: user-defined decimal places 0000h-0000b: no decimal place 0001h-0001b: one decimal place 0002h-0010b: two decimal places 0003h-0011b: three decimal places	353

		bit 4–15: user-defined unit 000xh: Hz 001xh: rpm 002xh: % 003xh: kg/cm2 004xh: m/s 005xh: kW 006xh: HP 007xh: ppm 008xh: 1/m 009xh: kg/s 00Axh: kg/m 00Bxh: kg/h 00Cxh: lb/s 00Dxh: lb/m 00Exh: lb/h 00Fxh: ft/s 010xh: ft/m 011xh: m 012xh: ft 013xh: degC 014xh: degF 015xh: mbar 016xh: bar 017xh: Pa 018xh: kPa 019xh: mWG 01Axh: inWG 01Bxh: ftWG 01Cxh: psi 01Dxh: atm 01Exh: L/s 01Fxh: L/m 020xh: L/h 021xh: m3/s 022xh: m3/h 023xh: GPM 024xh: CFM xxxxh: Hz	

00-26	Maximum user-defined value	0: No function 0–65535 (when Pr.00-25 is set to no decimal place) 0.0–6553.5 (when Pr.00-25 is set to one decimal place) 0.00–655.35 (when Pr.00-25 is set to two decimal places) 0.000–65.535 (when Pr.00-25 is set to three decimal places)	0
01-12	Acceleration time 1	Pr.01-45 = 0: 0.00–600.00 sec. Pr.01-45 = 1: 0.0–6000.0 sec.	10.00 10.0
01-13	Deceleration time 1	Pr.01-45 = 0: 0.00–600.00 sec. Pr.01-45 = 1: 0.0–6000.0 sec.	10.00 10.0
01-15	Deceleration time 2	Pr.01-45 = 0: 0.00–600.00 sec. Pr.01-45 = 1: 0.0–6000.0 sec.	10.00 10.0
04-57	Pump system configuration setting	bit 0–3 00x0h: Digital keypad 00x1h: RS-485 communication 00x8h: Communication card (does not include CANopen card) bit 4–7 000xh: Digital keypad 001xh: RS-485 communication 002xh: External terminals (MI1) 005xh: Communication card (does not include CANopen card)	0
05-31	Accumulated motor operation time (minutes)	0-1439	0
05-32	Accumulated motor operation time (days)	0~65535	0
06-17	Fault record 1	0: No fault record 1: Over-current during acceleration (ocA)	100

		2: Over-current during deceleration (ocd) 3: Over-current during steady operation (ocn) 4: Ground fault (GFF) 6: Over-current at stop (ocS) 7: Over-voltage during acceleration (ovA) 8: Over-voltage during deceleration (ovd) 9: Over-voltage during constant speed (ovn) 10: Over-voltage at stop (ovS) 11: Low-voltage during acceleration (LvA) 12: Low-voltage during deceleration (Lvd) 13: Low-voltage at constant speed (Lvn) 14: Low-voltage at stop (LvS) 15: Phase loss protection (orP) 16: IGBT overheating (oH1) 17: Heatsink overheating (oH2) 18: IGBT temperature detection failure (tH1o) 19: Capacitor hardware error (tH2o) 21: Over load (oL) 22: Electronics thermal relay 1 protection (EoL1) 24: Motor overheating PTC-130 / KTY-84-130 / PT100 (oH3) 26: Over torque 1 (ot1) 28: Under current (uC) 31: EEPROM read error (cF2) 33: U-phase error (cd1) 34: V-phase error (cd2) 35: W-phase error (cd3) 36: cc hardware error (Hd0) 37: oc hardware error (Hd1) 40: Auto-tuning error (AUE) 41: PID loss ACI (AFE) 48: ACI loss (ACE) 49: External fault (EF) 51: External base block (bb) 52: Password is locked (Pcod) 54: Illegal command (CE1) 55: Illegal data address (CE2) 56: Illegal data value (CE3)	

		57: Data is written to read-only address (CE4) 58: Modbus transmission time-out (CE10) 79: U-phase over-current before run (Aoc) 80: V-phase over-current before run (boc) 81: W-phase over-current before run (coc) 82: U-phase output phase loss (oPL1) 83: Output phase loss V phase (oPL2) 84: Output phase loss W phase (oPL3) 87: Low frequency overload protection (oL3) 89: Rotor position detection error (roPd) 90: Force to stop (FStp) 98: Fire mode output (Fire) 140: oc hardware error (Hd6) 141: GFF occurs before run (b4GFF) 142: Auto-tune error 1 (AuE1) (DC test stage) 143: Auto-tune error 2 (AuE2) (high frequency stall stage) 144: Auto-tune error 3 (AuE3) (rotation test stage) 221: High water pressure (HPS) 222: Low water pressure (LPSE) 223: Dry pump (dryE) 224: Water leaking (pipe explosion) (LEKE) 225: Clogged pipe (JAME) 226: RTC error (rtF) 227: Dry pump curve auto-measuring (dAUE)	
08-00	Terminal selection of PID Feedback	0: No function 1: Negative PID feedback: by analog input (Pr.03-00)	0
08-01	Proportional gain (P)	0.0–500.0 (when Pr.08-23 set bit1 = 0) 0.00–5000.0 (when Pr.08-23 set bit1 = 1)	1.00
08-02	Integral time (I)	0.00–100.00 sec.	1.00
08-03	Differential time (D)	0.00–1.00 sec.	0.00
09-00	Communication address	1-8	1
09-01	COM1 transmission	4.8–115.2 Kbps	9.6

	speed		
09-02	COM1 transmission fault treatment	0: Warn and continue operation 1: Fault and ramp to stop 2: Fault and coast to stop 3: No warning, no fault and continue operation	3
09-03	COM1 time-out detection	10.0–100.0 sec.	0.0
09-04	COM1 communication protocol	1: 7, N, 2 (ASCII) 2: 7, E, 1 (ASCII) 3: 7, O, 1 (ASCII) 4: 7, E, 2 (ASCII) 5: 7, O, 2 (ASCII) 6: 8, N, 1 (ASCII) 7: 8, N, 2 (ASCII) 8: 8, E, 1 (ASCII) 9: 8, O, 1 (ASCII) 10: 8, E, 2 (ASCII) 11: 8, O, 2 (ASCII) 12: 8, N, 1 (RTU) 13: 8, N, 2 (RTU) 14: 8, E, 1 (RTU) 15: 8, O, 1 (RTU) 16: 8, E, 2 (RTU) 17: 8, O, 2 (RTU)	1
09-31	COM1 internal communication protocol	0: Modbus 485 -12: Modbus master (for PLC) -21: ID1 (pump master) -22: ID2 (pump slave) -23: ID3 (pump slave) -24: ID4 (pump slave) -25: ID5 (pump slave) -26: ID6 (pump slave) -27: ID7 (pump slave) -28: ID8 (pump slave)	0
12-00	Set point deviation level (Sleep and pump	0–50%	0

	remove frequency in % of set point)		
12-01	Detection time of set point deviation level (Sleep and pump remove delay)	1–9999 sec.	10
12-02	Offset level of low water consumption (Immediate wake frequency in % of set point)	0-50%	10
12-03	Offset level of high water consumption (Delayed wake frequency in % of set point)	0: No function 0–100%	0
12-04	High water consumption delay time (Wake delay)	0: No function 0.1–10.0 sec.	0.5
12-08	Pump add frequency	Pr.12-10–FMAX	FMAX
12-09	Pump add delay	0.0–3600.0 sec.	1.0
12-10	Pump stop frequency	0.00-150.00 Hz	80.00
12-13	Treatment of pump fault	Bit 0: Fault action 0: Stop all pumps 1: Switch to another pump Bit 1: Reset action 0: Standby after resetting 1: Stop after resetting Bit 2: Fault at start action 0: Stop all pumps 1: Switch to another pump	1
12-14	Selection of pump	0: According to the serial numbers of the pumps	1

	start-up sequence	1: According to the operating time	
12-50	Cycle time selection	0: No function 1: Absolute time 2: Fixed time	2
12-51	Multi-pump's absolute time circulation period	00:00-23:59	00:00
12-52	Multi-pump's fixed time circulation period	0.0–3000.0 hours	5.0
12-79	Level of high pressure alarm	0: No function 1–50%	25
12-80	High pressure time delay	0.1–300.0 sec.	5.0
12-81	Treatment of high pressure	1: Fault and coast to stop 2: Fault and ramp to stop	1
12-82	Level of low pressure alarm	0: No function 1–50%	25
12-83	Low pressure time delay	0.1–300.0 sec.	5.0
12-84	Treatment of low pressure	0: Warn and continue operation 1: Fault and coast to stop 2: Fault and ramp to stop	1

4.2.3 Parameter Description

The following descriptions relate to the IPC function. Parameters may operate in a different manner, when it is not in use. Please refer to the drive's user manual when the IPC function is not in use.

00-02 Parameter Reset

Default: 0

Settings: 0: No function
1: Write protection for parameters

5: Return kWh displays to 0
6: Reset PLC
8: Keypad does not respond
10: Reset all parameters to defaults (base frequency is 150 Hz)
12: Reset all parameters to defaults with base frequency at 150 Hz (keep the user-defined parameter values Pr.13-01-Pr.13-50)
110: Load IPC function program into PLC

- 1: All parameters are read-only except Pr.00-02, Pr.00-07, and Pr.00-08. Set Pr.00-02 to 0 before changing other parameter settings
- 5: You can return the kWh displayed value to 0 even during drive operation. For example, you can set Pr.05-26–Pr.05-30 to 0
- 6: Clear the internal PLC program (includes the related settings of PLC internal CANopen master)
- 10: Reset all parameters to defaults. If you have set a password (Pr.00-08), unlock the password (Pr.00-07) to clear the password you have set before you reset all parameters
- 110: The drive comes without PLC program to offer the full 14 k program steps. Pr.00-02 = 110 will load the IPC function program into the PLC. If the program is not needed, Pr.00-02 = 6 will free the PLC memory again

For the setting of 10, you must reboot the motor drive after you finish the setting.

00-20 Master frequency command source (AUTO, REMOTE)

Default: 0

Settings: 0: Digital keypad
1: RS-485 communication input (COM1)
2: External analog input (refer to Pr.03-00)
3: External UP / DOWN terminal (multi-function input terminals)
8: Communication card (does not include CANopen card)
Note: HOA (Hand-Off-Auto) function is valid only when you use with MO function setting 42 and 56.

- Must be set to Pr.00-20 = 1 for IPC function
- Refer to Pr.04-57 bits 0-3 for frequency source setting

00-21 Operation Command (AUTO) Source

Default: 0

Settings: 0: Digital keypad
1: External terminals
2: RS-485 communication input (COM1)
5: Communication card (does not include CANopen card)

Note: HOA (Hand-Off-Auto) function is valid only when you use with MO function setting 42 and 56.

📖 Must be set to Pr.00-21 = 2 for IPC function

📖 Refer to Pr.04-57 bits 4-7 for command source setting

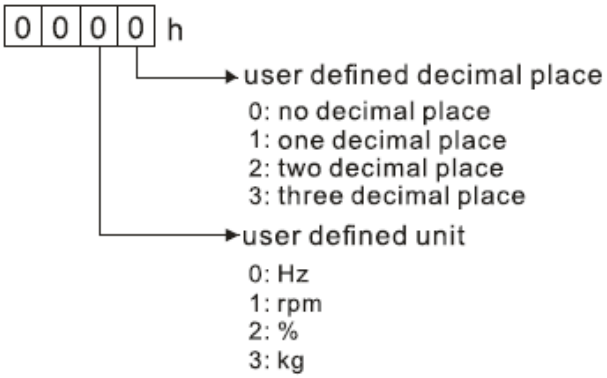
00-25 Maximum User-Defined Value

Default: 0

Settings: Bit0–3: user-defined decimal place
0000b: no decimal place
0001b: one decimal place
0010b: two decimal places
0011b: three decimal places
Bit4–15: user-defined unit
000xh: Hz
001xh: rpm
002xh: %
003xh: kg
004xh: m/s
005xh: kW
006xh: HP
007xh: ppm
008xh: 1/m
009xh: kg/s
00Axh: kg/m
00Bxh: kg/h
00Cxh: lb/s
00Dxh: lb/m
00Exh: lb/h
00Fxh: ft/s
010xh: ft/m
011xh: m
012xh: ft
013xh: degC
014xh: degF
015xh: mbar
016xh: bar
017xh: Pa
019xh: mWG
01Axh: inWG

01Bxh: ftWG
01Cxh: psi
01Cxh: psi
01Dxh: atm
01Exh: L/s
01Fxh: L/m
020xh: L/h
021xh: m3/s
022xh: m3/h
023xh: GPM
024xh: CFM
xxxxh: Hz

- Bit0–3: the displayed units for the control frequency F page and user-defined (Pr.00-04 = d10 PID feedback) and the displayed number of decimal places for Pr.00-26 (supports up to three decimal places)
- Bit4–15: the displayed units for the control frequency F page, user-defined (Pr.00-04 = d10, PID feedback) and Pr.00-26



- You must convert the setting value to decimal when using the keypad to set parameters

  Example: Assume that the user-defined unit is inWG and user-defined decimal place is the third decimal point. According to the information above, the corresponding unit to inWG is 01Axh (x is the set decimal point), and the corresponding unit to the third decimal place is 0003h, then inWG and the third decimal point displayed in hexadecimal is 01A3h, that is 419 in decimal value. Thus, set Pr.00-25 = 419 to complete the setting

00-26 Maximum User-Defined Value

Default: 0

Settings: 0: Disable

0–65535 (when Pr.00-25 is set to no decimal place)
0.0–6553.5 (when Pr.00-25 is set to one decimal place)
0.00–655.35 (when Pr.00-25 is set to two decimal places)
0.000–65.535 (when Pr.00-25 is set to three decimal places)

📖 When Pr.00-26 is NOT set to 0, the user-defined value is enabled. After selecting the displayed unit and number of decimal places with Pr.00-25, the setting value of Pr.00-26 corresponds to Pr.01-00 (drive's maximum operating frequency).
Example: When the frequency set in Pr.01-00 = 60.00 Hz, the maximum user-defined value for Pr.00-26 is 100.0%. This also means that Pr.00-25 is set as 0021h

✎ NOTE Set Pr.00-25 before using Pr.00-26. After you finish setting, when Pr.00-26 is not 0, the displayed unit on the keypad shows correctly according to Pr.00-25 settings.

00-32 Slave Pump Maintenance Switch

Default: 0

Settings: 0: Normal operation
1: Enable maintenance

📖 When Pr.00-32 = 1, press the STOP key to stop the slave pump. The keypad will show FSTP

📖 When maintenance is finished, press STOP again to re-enable the slave. Press RESET to clear the FSTP error. The pump will start its normal operation again

02-00 Pump System Configuration Setting Two-wire / Three-wire Operation Control

Default: 1

Settings: 0: No function
1: Two-wire mode 1, power ON for operation control
(MI1: FWD / STOP, MI2: REV / STOP)
2: Two-wire mode 2, power ON for operation control
(MI1: RUN / STOP, MI2: REV / FWD)
3: Three-wire, power ON for operation control
(MI1: RUN, MI2: REV / FWD, MI3: STOP)
4: Two-wire mode 1, Quick Start
(MI1: FWD / STOP, MI2: REV / STOP)
5: Two-wire mode 2, Quick Start
(MI1: RUN / STOP, MI2: REV / FWD)
6: Three-wire, Quick Start

(MI1: RUN, MI2: REV / FWD, MI3: STOP)

📖 After enabling the built-in PLC function, Pr.02-00 has no function.
Pr.04-57 ≠ 0: MI1 has no function.
Pr.04-57 = 0: MI1: IPC RUN.
Users can set MI2, MI3 according to Pr.02-02 and Pr.02-03

03-19 Signal Loss Selection For AI1 Analog Input 4–20 mA

Default: 0

Settings: 0: Disabled
1: Continue operation at the last frequency
2: Decelerate to 0 Hz
3: Stop immediately and display ACE

📖 0: No warning

📖 1: If the analog signal is lost, ANL warning occurs. The drive keeps operating according to the command from communication master. If there is no communication master, then it operates according to Pr.12-12

📖 2: Disabled

📖 3: If the analog signal is lost, an ACE fault shows on the keypad and IPC stops

04-57 Pump System Configuration Setting

Default: 0

Settings: Bit 0-3 Source of frequency command
00x0h: Digital keypad
00x1h: RS-485 communication (COM2)
00x8h: Communication card (does not include CANopen card)
Bit 4-7 Source of operation command
000xh: Digital keypad
001xh: RS-485 communication (COM2)
002xh: External terminals (MI1)
005xh: Communication card (does not include CANopen card)
Bit 8 Set to be backup master
Bit 9 Display a PL00 warning when the backup master becomes the master

📖 This parameter is to set the multi-pump configuration of the built-in PLC function.

Refer to user manual, chapter 15 PLC Function Applications for the way to enable the built-in PLC function

🕮 Due the settings according to the different system statuses, refer to the table below. Because the backup master continues to operate with the last known pressure command from the master, it's invalid to set the source of frequency command in it

Pr.04-57	Applicable to
Bit 0-3 Source of frequency command	Master (station address 1)
Bit 4-7 Source of operation command	Master (station address 1) Backup master
Bit 8 Set to be backup master	Backup master
Bit 9 Display a PL00 warning when the backup master becomes the master	Backup master

🕮 Example: When a multi-pump system is established, the AC motor drives connect with each other by Modbus communication, thus Pr.00-20, Pr.00-21 have to be RS-485 (COM1). The default settings of Pr.04-57 for the master drive are frequency and operation command by keypad. For control from a Modbus master, like an HMI, set Pr.04-57 = 0011h and use COM2

🕮 When switching the frequency command source, the system takes the present source of frequency as a reference of target pressure. For example, if the frequency command is from the communication card, the system operates with 10 bar according to the target pressure of the communication card, but when the frequency command is from Modbus, the system operates with 4 bar according to the target pressure of Modbus

🕮 Refer to Pr.02-00 for more details about operation command from MI1, when Pr04-57 = 002xh

Source of operation command / Source of frequency command	000xh: Digital keypad	001xh: RS-485 communication	002xh: External terminal (MI1)	005xh: Communication card (does not include CANopen card)
00x0h:	Hex: 0000h	Hex: 0010h	Hex: 0020h	Hex: 0050h

Digital keypad	Decimal: 0	Decimal: 16	Decimal: 32	Decimal: 80
00x1h: RS-485 communication	Hex: 0001h Decimal: 1	Hex: 011h Decimal: 17	Hex: 021h Decimal: 33	Hex: 051h Decimal: 81
00x8h: Communication card (does not include CANopen card)	Hex: 0008h Decimal: 8	Hex: 0018h Decimal: 24	Hex: 0028h Decimal: 40	Hex: 0058h Decimal: 88

🕮 Bit 8: Set to be backup master. If you want the station address to be backup master, then set bit 8 to be 1, and key in 256

🕮 Bit 9: If you want a warning is displayed on the digital keypad when the backup master switches, then set bit 9 to be 768 to display PL00 warning

09-00 Communication Address

Default: 1

Settings: 1-254

🕮 Sets the communication address of the drive for RS-485 serial communication. The communication address for each AC motor drive and PLC must be unique

🕮 In IPC mode, only the following settings are allowed
Master drive = 1
Backup master drive = 2-8
Slave drive = 1-8
Make sure that each address is unique

09-01 COM1 Transmission Speed

Default: 9.6

Settings: 4.8–115.2 kbps

🕮 Sets the transmission speed between the computer and the AC motor drive

🕮 Options are 4.8 Kbps, 9.6 Kbps, 19.2 Kbps, 38.4 Kbps, 57.6 Kbps or 115.2 Kbps. Otherwise, the transmission speed is set to the default 9.6 Kbps

🕮 Upon activation of the PLC in IPC mode, this parameter will be modified automatically to Pr.09-01 = 14, i.e. 115.2 kbps

09-02 COM1 Transmission Fault Treatment

Default: 3

Settings: 0: Warn and continue operation
1: Fault and ramp to stop
2: Fault and coast to stop
3: No warning, no fault and continue operation

🕮 Determines the error reaction when the host controller does not continuously transmit data to the AC motor drive during Modbus communication. The detection time is based on the Pr.09-03 setting

09-03 COM1 Time-out Detection

Default: 0

Settings: 0.0–100.0 [s]

🕮 Sets the communication transmission time-out value

🕮 In IPC mode, the suggested setting is ≥ 10.0 s

09-04 COM1 Communication Protocol

Default: 1

Settings: 1: 7, N, 2 (ASCII)
2: 7, E, 1 (ASCII)
3: 7, O, 1 (ASCII)
4: 7, E, 2 (ASCII)
5: 7, O, 2 (ASCII)
6: 8, N, 1 (ASCII)
7: 8, N, 2 (ASCII)
8: 8, E, 1 (ASCII)
9: 8, O, 1 (ASCII)
10: 8, E, 2 (ASCII)
11: 8, O, 2 (ASCII)
12: 8, N, 1 (RTU)
13: 8, N, 2 (RTU)
14: 8, E, 1 (RTU)
15: 8, O, 1 (RTU)
16: 8, E, 2 (RTU)

17: 8, O, 2 (RTU)

🕮 Upon activation of the PLC in IPC mode, this parameter will be modified automatically to Pr.09-02 = 14, i.e. 8, E, 1 (RTU)

🕮 This value will change to Pr.09-02 = 12, i.e. 8, N, 1 (RTU), if the PLC is deactivated again immediately. It will remain Pr.09-14, if the PLC is deactivated at a later time

09-31 COM1 internal communication protocol

Default: 0

Settings: 0: Modbus 485
-12: Modbus master (for PLC)
-21: ID1 (Pump Master)
-22: ID2 (Pump Slave)
-23: ID3 (Pump Slave)
-24: ID4 (Pump Slave)
-25: ID5 (Pump Slave)
-26: ID6 (Pump Slave)
-27: ID7 (Pump Slave)
-28:ID8 (Pump Slave)

🕮 In IPC mode, the settings are automatic, i.e. -12 for the master drive and 0 for the slave drives

09-35 PLC Address

Default: 100

Settings: 1–254

🕮 Sets the communication address of the drive's integrated PLC for RS-485 serial communication. The communication address for each AC motor drive and PLC must be unique

12-12 Pump's Frequency At Time-Out (Disconnection)

Default: 0.00

Settings: 0.00–FMAX (01-00)

🕮 This parameter is only valid for slave pumps

🕮 Refer to Pr.09-02 (COM1 transmission fault handling) and Pr.09-03 (COM1 time-out

detection) for the communication failure conditions and fault handling

🕮 If a disconnection occurs in the multi-pump circumstances, the frequency command of the slave pump is Pr.12-12. The slave pump is in standalone mode after STOP commend is given. Set the RUN command and operation frequency by the slave pump parameters

🕮 The master pump has the function to re-detect if a slave pump is time-out

12-13 Treatment of Pump Fault

Default: 1

Settings: Bit 0: Fault action
0: Stop all pumps
1: Switch to another pump
Bit 1: Reset action
0: Standby after resetting
1: Stop after resetting
Bit 2: Fault at start action
0: Stop all pumps
1: Switch to another pump

🕮 This parameter is valid for the master pump

🕮 If the built-in PLC function is enabled, the value of the parameter is fixed to 5 (default)

🕮 This parameter only works under auto mode. If the pump switches to manual mode by setting MIx = 97 (multi-pump manual / auto switch) or if the STOP button on the keypad is pressed to disable multi-pump control, then the parameter setting does not affect the pump

🕮 Upon pump failure in the multi-pump system, the master pump determines the behaviour of the failing pump according to this parameter setting.

🕮 Bit 0: When the operating pump fails
Bit 0 = 0: Stop all pumps
Bit 0 = 1: Stop the failed pump, and keep operating with the next pump according to the priority setting

🕮 Bit 1: Behaviour after error reset
Bit 1 = 0: Standby: After resetting, the pump accepts commands from the master drive
Bit 0 = 1: Stop: After resetting, the pump does not accept commands from the master drive until a system restart

🕮 Bit 2: Behaviour when an error exists at start

Bit2 = 0: Stop all pumps

Bit2 = 1: Start and replace the failed pump with another one

4.2.4 Troubleshooting

This chapter refers to IPC-related warnings and errors only. For other issues, please check the drive's user manual.

Item	Description		
ACI analog signal loss	Analog input current loss (including all analog 4–20 mA signals)		
Action and Reset			
Action condition	When the analog input is lower than 4 mA (only detects analog input 4–20 mA).		
Action Level	< 4 mA		
Action Time	Immediate		
Warning ID	12	Warning name	ACI analog signal loss (AnL)
Warning display	AnL		
Warning treatment	Pr.03-19 1: Continue operation at the last frequency (warning, the keypad displays "ANL") 2: Decelerate to 0 Hz (warning, the keypad displays "ANL")		
Reset method	Automatic reset when the feedback signal is larger than 4 mA.		
Reset condition	Immediately reset		
Record	No		
Fault ID	41	Fault name	PID loss AI1 (AFE)
Fault display	ACE		
Fault treatment	Pr.03-19		

	3: Stop immediately and display “ACE”		
Reset method	Manual reset		
Reset condition	Immediately reset		
Record	Yes		
Cause	Corrective Action		
PID feedback cable is disconnected or defective	Reconnect and tighten the terminal. Replace the cable with a new one.		
Feedback device failure	Replace the device with a new one.		
Hardware failure	- Provide a 4-20 mA signal to AI1 - Set Pr.00-04 = 11 - Check the feedback signal on the keypad display - If the display does not correspond to the input signal, contact Delta.		
Item	Description		
PID feedback loss	PID feedback loss (warning for analog feedback signal; works only when PID is enabled)		
Action and Reset			
Action condition	When the analog input is lower than 4 mA (only detects analog input 4–20 mA).		
Action Level	< 4 mA		
Action Time	Pr.08-08		
Warning ID	11	Warning name	PID feedback error (PID)
Warning display	PID		
Warning treatment	Pr.08-09		

	0: Warn and keep operation 3: Warn and operate at last frequency		
Reset method	Automatic reset when the feedback signal is larger than 4 mA.		
Reset condition	Immediately reset		
Record	No		
Fault ID	41	Fault name	PID loss AI1 (AFE)
Fault display	AFE		
Fault treatment	Pr.08-09 1: Warn and ramp to stop 2: Warn and coast to stop		
Reset method	Manual reset		
Reset condition	Immediately reset		
Record	Yes		
Cause	Corrective Action		
PID feedback cable is disconnected or defective	Reconnect and tighten the terminal. Replace the cable with a new one.		
Feedback device failure	Replace the device with a new one.		
Hardware failure	- Provide a 4-20 mA signal to AI1 - Set Pr.00-04 = 11 - Check the feedback signal on the keypad display - If the display does not correspond to the input signal, contact Delta.		

Item	Description
Modbus timeout	Modbus transmission timeout occurs

Action and Reset			
Action condition	When the communication time exceeds the detection time for Pr.09-03 time-out.		
Action Time	Pr.09-03		
Warn ID	5	Fault name	Communication error 10 (CE10)
Warn display	CE10		
Fault treatment	Pr.09-02 0: Warn and continue operation 3: No warning and continue operation		
Reset method	Auto reset when receiving the next communication packet.		
Reset condition	Immediately reset		
Record	Yes		
Fault ID	58	Fault name	Modbus transmission time-out (CE10)
Fault display	CE10		
Fault treatment	Pr.09-02 1: Fault and ramp to stop 2: Fault and coast to stop 3: No warning and continue operation		
Reset method	Manual reset		
Reset condition	Immediately reset		
Record	Yes		
Cause	Corrective Action		
The upper unit does not transmit the communication command within	Check if the upper unit transmits the communication command within the setting time for Pr.09-03.		

Pr.09-03 setting time	
Malfunction caused by interference	Verify the wiring and grounding of the communication circuit. It is recommended to separate the communication circuit from the main circuit, or wire in 90 degree for effective anti-interference performance.
Different communication setting from the upper unit	Check if the setting for Pr.09-01 and Pr.09-04 are the same as the setting for the upper unit.
Disconnection or bad connection of the cable	Check the cable and replace it if necessary.

Item	Description		
Dry-run auto tuning error	The high-speed power cannot be lower than the low speed power, and cannot exceed the drive power. Give STOP command when fault occurs during auto-detection. High speed power Pr.12-67 Low speed power Pr.12-66		
Action and Reset			
Action condition	The power after adjusting does not comply with the power value		
Action Time	Immediate		
Fault ID	227	Fault name	Dry pump curve auto-measuring (dAUE)
Fault display	dAUE		
Fault treatment	Fault and coast to stop		
Reset method	Manual reset		

Reset condition	Immediately reset. Parameters not stored
Record	Yes
Cause	Corrective Action
The value auto-detect by the dry pump curve is abnormal	Restart the auto-tuning load curve, set Pr.12-65=1 to execute it.

Item	Description		
Dry-run	Dry pump condition is detected.		
Action and Reset			
Action condition	The power that corresponds to the target frequency is under the dry pump curve.		
Action Time	Pr.12-69		
Warning ID	223	Warning name	Dry pump (dryn)
Warning display	drYn		
Warning treatment	Pr.12-72 1: Fault and coast to stop 2: Fault and ramp to stop		
Reset method	Auto-reset when the triggered condition is clear.		
Reset condition	Immediately reset		
Record	No		
Fault ID	223	Fault name	Dry pump (dryE)
Fault display	drYE		
Fault treatment	Fault and coast to stop The pump restarts until the count of restart times exceeds the		

	setting in Pr.12-71
Reset method	Manual reset
Reset condition	Immediately reset
Record	Yes
Cause	Corrective Action
The supply to the water pump inlet is interrupted	Check - If the supply pipe is defective - If the supply source is full - If any valves before the pump are closed
The pump outlet is closed	Check - If any valves behind the pump are closed - If the pipe behind the pump is obstructed

Item	Description		
High pressure fault	The feedback pressure is too high		
Action and Reset			
Action level	The feedback pressure is higher than the setting in Pr.12-79, for longer than the time setting in Pr.12-79.		
Action Time	Pr.12-80		
Fault ID	222	Fault name	High water pressure (HPS)
Fault display	HPS		
Fault treatment	Pr.12-81 1: Fault and coast to stop 2: Fault and ramp to stop		
Reset method	Manual reset		

Reset condition	Immediately reset
Record	Yes
Cause	Corrective Action
The pressure sensor is broken	Replace the pressure sensor
The disconnection frequency setting of pump is too high	Decrease the setting value in Pr.12-12

Item	Description		
Clogging	The current is too high due to pump clogging		
Action and Reset			
Action condition	After cleaning as many times as set in Pr.12-58, the current is higher than Pr.12-54.		
Action Time	Immediate		
Fault ID	225	Fault name	Clogged pipe (JAME)
Fault display	JAME		
Fault treatment	Fault and coast to stop		
Reset method	Manual reset		
Reset condition	Immediately reset		
Record	Yes		
Cause	Corrective Action		
The pump vane or impeller is contaminated	Manual cleaning, because the automatic cleaning cannot remove the contamination		

Item	Description		
Broken pipe	Severe water leakage detected.		
Action and Reset			
Action condition	When the feedback is lower than Pr.12-73 and the load current is higher than Pr.12-75		
Action Time	Pr.12-74		
Warning ID	224	Warning name	Heavy water leakage (LEKn)
Warning display	LEKn		
Warning treatment	Pr.12-76 0: Warn and continue operation		
Reset method	Auto-reset when the triggered condition is clear.		
Reset condition	When the feedback is higher than Pr.12-73 and the load current is lower than Pr. 12-75		
Record	No		
Fault ID	224	Fault name	Water leaking (pipe rupture) (LEKE)
Fault display	LEKE		
Fault treatment	Pr.12-76 1: Fault and coast to stop 2: Fault and ramp to stop		
Reset method	Manual reset		
Reset condition	Immediately reset		
Record	Yes		
Cause	Corrective Action		
There is a leakage behind the pump	Check - The piping for ruptures		

outlet	- All flanges, seals, gaskets and valves for tightness - Whether the demand is above the pump specifications

Item	Description		
Low pressure fault	The feedback pressure is too high		
Action and Reset			
Action condition	The feedback pressure is lower than the difference between Pr.12-82 and the target pressure for longer than the time value set in Pr.12-83.		
Action Time	Pr.12-83		
Warning ID	222	Warning name	Low water pressure (LPSn)
Warning display	LPSn		
Warning treatment	Pr12-84 0: Warn and continue operation		
Reset method	Auto-reset when the triggered condition is clear.		
Reset condition	Immediately reset		
Record	No		
Fault ID	222	Fault name	Low water pressure (LPSE)
Fault display	LPSE		
Fault treatment	Pr.12-84 1: Fault and coast to stop 2: Fault and ramp to stop		
Reset method	Manual reset		
Reset condition	Immediately reset		
Record	Yes		

Cause	Corrective Action
Insufficient outlet pressure	Check for leakages. Make sure that there is sufficient supply at the pump inlet.
Feedback sensor failure	Repair or replace the sensor

Item	Description		
Master drive change	In IPC mode, backup drive becomes master drive		
Action and Reset			
Action condition	Pr.04-57 bit9=1 and the master drive or communication fails		
Action Time	Immediate		
Warning ID	99	Warning name	PLC warning (PL00)
Warning display	PL00		
Warning treatment	None		
Reset method	Auto-reset		
Reset condition	Pr.04-57 bit9 = 1 or the backup drive returns to be slave drive		
Record	No		
Cause	Corrective Action		
The backup drive becomes the master drive when the original master drive fails, is disconnected or the experiences a power supply failure	Check for anomalies in the original master drive.		