PowerXL™

DG1 Variable Frequency Drives
DG1 in Pump and Fan Applications

Level 3	1 – Fundamental – No previous experience necessary 2 – Basic – Basic knowledge recommended 3 – Advanced – Reasonable knowledge required 4 – Expert – Good experience recommended

Powering Business Worldwide

Contents

Danger! - Dangerous electrical voltage!

- Disconnect the power supply of the device.
- Ensure that devices cannot be accidentally restarted.
- Verify isolation from the supply.
- Cover or enclose any adjacent live components.
- Follow the engineering instructions (AWA/IL) for the device concerned.
- Only suitably qualified personnel in accordance with EN 50110-1/-2 (VDE 0105 Part 100) may work on this device/system.
- Before installation and before touching the device ensure that you are free of electrostatic charge.
- The functional earth (FE, PES) must be connected to the protective earth (PE) or the potential equalization. The system installer is responsible for implementing this connection.
- Connecting cables and signal lines should be installed so that inductive or capacitive interference does not impair the automatic control functions.
- Suitable safety hardware and software measures should be implemented for the I/O interface so that an open circuit on the signal side does not result in undefined states.
- Deviations of the mains voltage from the rated value must not exceed the tolerance limits given in the specification, otherwise this may cause malfunction and/or dangerous operation.
- Emergency stop devices complying with IEC/EN 60204-1 must be effective in all operating modes. Unlatching of the emergency-stop devices must not cause a restart.
- Devices that are designed for mounting in housings or control cabinets must only be operated and controlled after they have been properly installed and with the housing closed.
- Wherever faults may cause injury or material damage, external measures must be implemented to ensure a safe operating state in the event of a fault or malfunction (e.g. by means of separate limit switches, mechanical interlocks etc.).
- Frequency inverters may have hot surfaces during and immediately after operation.
- Removal of the required covers, improper installation or incorrect operation of motor or frequency inverter may destroy the device and may lead to serious injury or damage.
- The applicable national safety regulations and accident prevention recommendations must be applied to all work carried on live frequency inverters.
- The electrical installation must be carried out in accordance with the relevant electrical regulations (e. g. with regard to cable cross sections, fuses, PE).
- Transport, installation, commissioning and maintenance work must be carried out only by qualified personnel (IEC 60364, HD 384 and national occupational safety regulations).
- Installations containing frequency inverters must be provided with additional monitoring and protective devices in accordance with the applicable safety regulations. Modifications to the frequency inverters using the operating software are permitted.
- All covers and doors must be kept closed during operation.
- To reduce the hazards for people or equipment, the user must include in the machine design measures that restrict the consequences of a malfunction or failure of the frequency inverter (increased motor speed or sudden standstill of motor). These measures include: – Other independent devices for monitoring safety related variables (speed, travel, end positions etc.).
    - Electrical or non-electrical system-wide measures (electrical or mechanical interlocks).

Never touch live parts or cable connections of the frequency inverter after it has been disconnected from the power supply. Due to the charge in the capacitors, these parts may still be alive after disconnection. Consider appropriate warning signs

Disclaimer

The information, recommendations, descriptions, and safety notations in this document are based on Eaton's experience and judgment and may not cover all contingencies. If further information is required, an Eaton sales office should be consulted. Sale of the product shown in this literature is subject to the terms and conditions outlined in the applicable Terms and Conditions for Sale of Eaton or other contractual agreement between Eaton and the purchaser. THERE ARE NO UNDERSTANDINGS, AGREEMENTS, WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING WARRANTIES OF FITNESS FOR A PARTICULAR PURPOSE OR MERCHANTABILITY, OTHER THAN THOSE SPECIFICALLY SET OUT IN ANY EXISTING CONTRACT BETWEEN THE PARTIES. ANY SUCH CONTRACT STATES THE ENTIRE OBLIGATION OF EATON. THE CONTENTS OF THIS DOCUMENT SHALL NOT BECOME PART OF OR MODIFY ANY CONTRACT BETWEEN THE PARTIES. As far as applicable mandatory law allows so, in no event will Eaton be responsible to the purchaser or user in contract, in tort (including negligence), strict liability, or otherwise for any special, indirect, incidental, or consequential damage or loss whatsoever, including but not limited to damage or loss of use of equipment, plant or power system, cost of capital, loss of power, additional expenses in the use of existing power facilities, or claims against the purchaser or user by its customers resulting from the use of the information, recommendations, and descriptions contained herein. The information contained in this manual is subject to change without notice.

1 General

Energy efficiency is an important subject today. Turbo engines like pumps and fans are identified as applications with big possible savings. Valves and dampers, which are often used to vary the flow rates, are very lossy. To the greatest possible extend, one abstains from the mechanical and hydraulic flow rate adjustment and varies the speed of pumps and fans to gain energy savings.

In many applications there is an interaction between multiple units, which are activated and deactivated according to the demand and certain system conditions.

Devices of the series **PowerXL™ DG1** have an internal logic, which reflects the correlations and dependencies already to simplify the application. The following constellations are taken into account:

- Speed controlled stand alone drive
- Multipump (MPC = Multi Pump Control), where multiple motors work inside one system. Only one motor is speed controlled. The other motors are controlled with motor starters and run with a fixed speed. They are activated and deactivated by the variable frequency drive DG1.
- Multipump (MPC) with multiple speed controlled motors, where one variable frequency drive is acting as a master and the other ones as slaves, controlled by the master drive.

In addition the topic „availability“ (redundancy) is described as well as some functions like damper control, pipe fill …, which are typical in applications of turbo engines.

Quite often the internal PID controller is used to control the system pressure. The description of the PID controller itself is not part of this document, but handled inside the Application Note AP040164EN.

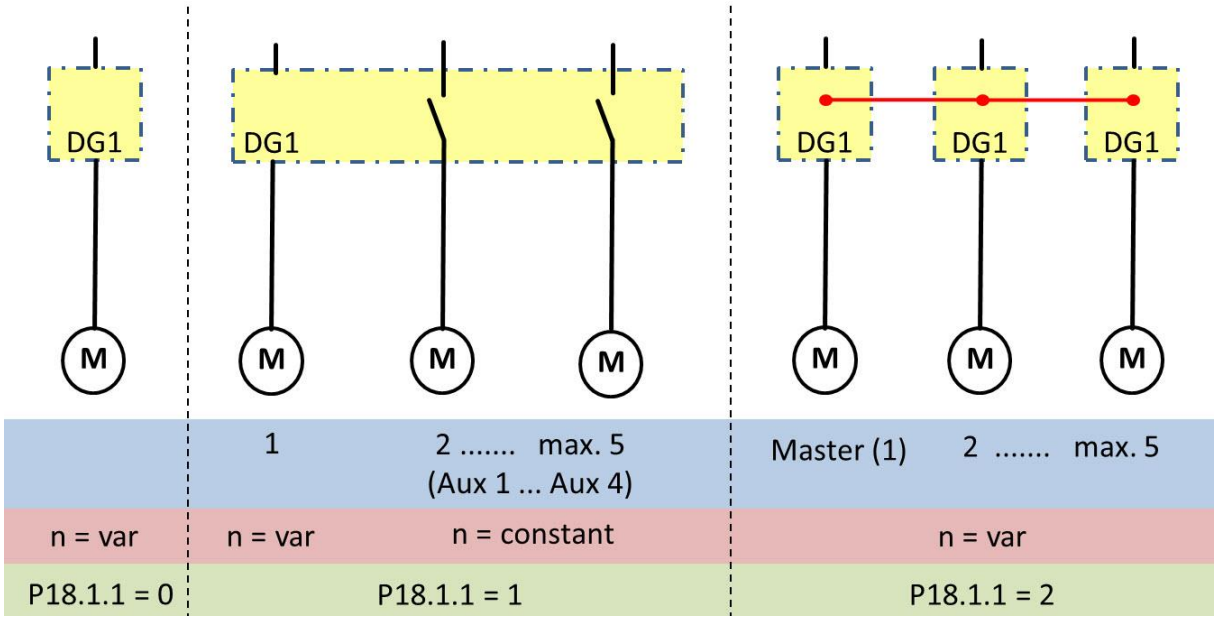
The functions described here, refer to an application software version 2.00.0004 (which is software bundle DG1-V0035-ETN) and above (see parameter P21.2.3 and P21.2.4). It is available in the following applications (P21.1.2):

- Multi-Pump
- Multi-PID
- Multi-Purpose

In case the application requires functions, which are not described inside this document, it is recommended to select P21.1.2 = Multi-Purpose, to have all parameters available. A later change of P21.1.2 leads to a reset of all parameters back to the default setting.

2 Selection of the operating mode

The setting of the DG1 parameters depends on the operating mode. The mode is selected with P18.1.1 „Multi-pump Mode“. There are three different configurations available, which are shown in the picture below. In this picture additional elements like protective devices or interlocks are intentionally not shown to highlight the differences between the operating modes in a clearer way.



P18.1.1 (P18.1.16) = Disabled (0)
The multi-pump mode is disabled. There is just one motor inside the system.

P18.1.1 (P18.1.16) = Single Drive Control (1)
The multi pump mode is activated. The system consists out of a speed controlled drive and up to 4 single speed motors, which are controlled by the variable frequency drive DG1. See chapter 4.1.

P18.1.1 (P18.1.16) = Multi Drive Network (2)
The multi pump mode is activated. The system consists exclusively out of up to 5 speed controlled motors. One drive acts as master and controls the other ones via a bus connection. See chapter 4.2.

The difference between the use of P18.1.1 and P18.1.16 is effective when "Multi Drive Network" is selected as the operating mode. See chapter 4.2.

P18.1.1 "Multi-Pump Mode"
When switching between the command sources defined with P1.11 and P1.12 and/or the reference sources defined with P1.14 and P1.15, control is still carried out via the network at the RS485 interface according to the master's specification.

P18.1.16 "Multi-Pump Mode 2”
When switching between the command sources defined with P1.11 and P1.12 and/or the reference sources defined with P1.14 and P1.15, the corresponding drive is disabled. The drive is then restarted via the corresponding command source.

P3.58 „Multi-Pump Mode 1/2 Select“
Selection between Multi-Pump Mode 1 (P18.1.1) and Multi-Pump Mode 2 (P18.1.16)
LOW = Multi-Pump Mode 1 (P18.1.1) active
HIGH = Multi-Pump Mode 2 (P18.1.16) active

Parameter	Name	Range	Default
P3.58	Multi-Pump Mode 1/2 Select	DigIN:NormallyOpen (0) DigIN:NormallyClose (1) DigIN 1 (2) DigIN 2 (3) DigIN 3 (4) DigIN 4 (5) DigIN 5 (6) DigIN 6 (7) DigIN 7 (8) DigIN 8 (9) DigIN: A: IO1: 1 (10) (on DXG-EXT-3DI3DO1T) DigIN: A: IO1: 2 (11) (on DXG-EXT-3DI3DO1T) DigIN: A: IO1: 3 (12) (on DXG-EXT-3DI3DO1T) DigIN: A: IO5: 1 (13) (on DXG-EXT-6DI) DigIN: A: IO5: 2 (14) (on DXG-EXT-6DI) DigIN: A: IO5: 3 (15) (on DXG-EXT-6DI) DigIN: A: IO5: 4 (16) (on DXG-EXT-6DI) DigIN: A: IO5: 5 (17) (on DXG-EXT-6DI) DigIN: A: IO5: 6 (18) (on DXG-EXT-6DI) DigIN: B: IO1: 1 (19) (on DXG-EXT-3DI3DO1T) DigIN: B: IO1: 2 (20) (on DXG-EXT-3DI3DO1T) DigIN: B: IO1: 3 (21) (on DXG-EXT-3DI3DO1T) DigIN: B: IO5: 1 (22) (on DXG-EXT-6DI) DigIN: B: IO5: 2 (23) (on DXG-EXT-6DI) DigIN: B: IO5: 3 (24) (on DXG-EXT-6DI) DigIN: B: IO5: 4 (25) (on DXG-EXT-6DI) DigIN: B: IO5: 5 (26) (on DXG-EXT-6DI) DigIN: B: IO5: 6 (27) (on DXG-EXT-6DI) Time Channel 1 (28) Time Channel 2 (29) Time Channel 3 (30) RO1 Function (31) RO2 Function (32) RO3 Function (33) Virtual RO1 Function (34) Virtual RO2 Function (35)	(0)
P18.1.1	Multi-Pump Mode 1	- Disabled (0) - Single Drive Control (1) - Multi Drive Network (2)	Disabled (0)
P18.1.16	Multi-Pump Mode 2	- Disabled (0) - Single Drive Control (1) - Multi Drive Network (2)	Disabled (0)

3 Application specific functions

3.1 Damper Start

Note: This function is not available in multi pump control mode (P18.1.1 “Multi-pump Mode” = 1 or 2).

This function is used to delay the start of a speed controlled motor, to bring other system elements like dampers and valves into the right position respectively to activate a lubricant pump.

P18.1.8 „Damper Start“:

- P18.1.8 = Normal (0)
    - The function is deactivated. The drive starts when the start signal is applied.
- P18.1.8 = Interlock Start (1)
    - To use this setting, a relay output (RO1. RO2 or RO3) has to be assigned to the function „Damper Control (35)“. In addition P3.9 „Run Enable“ has to be assigned to a digital input. When a start signal is applied, the relay contact closes and opens for example a lock valve. The position of the lock valve is fed back by an auxiliary contact to the digital input, defined with P3.9. When the signal is present at the input, the drive starts.
- P18.1.8 = Interlock Tout (2)
    - This setting basically works like the one described with P18.1.8 = 1. In addition there is a time monitoring, whose duration is set with P18.1.9 “Damper Time Out”. Is the feedback with the auxiliary contact not given within the time specified here, the drive trips and displays “Start-up prevent” and starting must be repeated.
- P18.1.8 = Interlock Delay (3)
    - This setting basically works like the one described with P18.1.8 = 1, but without a feedback by an auxiliary contact (no setting of P3.9 “Run Enable” is necessary). The drive starts after expiration of the time defined with P18.1.10 “Damper Delay”.

P18.1.9 „Damper Time Out“
This parameter is used when P18.1.8 is set to „2“. It defines the time in which the feedback signal of an auxiliary contact is expected. In case the time is exceeded, the drive trips and displays “Start-up prevent”.

P18.1.10 „Damper Delay“
This parameter is used when P18.1.8 is set to „3“. It defines the time after applying the start signal, at which the drive starts.

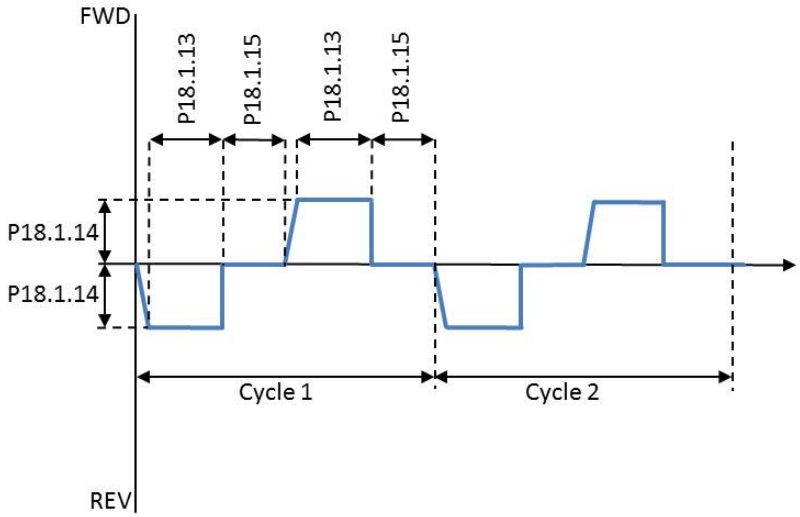
Parame-ter	Name	Range	Default
P3.9	Run Enable	DI = NormallyOpen (0) … DI…(…) … Virtual RO2 Function (35)	DI = NormallyC-lose (1)
P5.2 oder P5.3 oder P5.4	RO1 Function RO2 Function RO3 Function	Not Used (0) … Damper Control (35) … Run BypassDrive (60)	
P18.1.1	Multi-pump Mode	- Disabled (0) - Single Drive Control (1) - Multi Drive Network (2)	Disabled (0)
P18.1.8	Damper Start	- Normal (0) - Interlock Start (1) - Interlock Tout (2) - Interlock Delay (3)	Normal (0)
P18.1.9	Damper Time Out	1 – 32500 s	5 s
P18.1.10	Damper Delay	1 – 32500 s	5 s

3.2 Derag

After some time of operation, one can find debris inside tube systems, which can prevent a pump from starting because of mechanical blockage. In these cases the function “derag” can help. Inside a derag cycle the pump starts to turn backwards and then forwards to loosen the debris. The number of cycles can be selected as well as the speed in derag mode and the duration of the cycle.

Deragging can be performed either at each start or stop. The activation by a digital signal is possible as well. As soon as the deragging is activated, the drive stops its normal operation until the deragging is finished.

The diagram shows, how it works.



Note:
After starting, the pump cleaning process is also completed with a LOW signal on the start command. To interrupt this process a digital input P3.9 “Run Enable” must be configured.

P18.1.11 „Derag Cycles“
This parameter defines the number of cycles, each in forward and reverse direction, which are performed during one deragging.

P18.1.12 „Derag at Start/Stop“
Determines in which situations deragging shall be performed.

- P18.1.12 = „Off (0)“
  - Deragging is switched off.
- P18.1.12 = „Start (1)“
  - With each start signal the deragging starts. After completion of the set number of cycles the drive ramps to the set speed.
- P18.1.12 = „Stop (2)“
  - At each removal of the start signal the drive ramps to stop. At stand still deragging starts. After completion of the deragging the drive will be disabled except a start signal is present. When a start signal is applied during ramping down, this signal is ignored. A new start is only possible when the deragging is completed.
- P18.1.12 = „Start and Stop (3)“
  - The deragging starts with each application of a start signal as well as at each removal (combination out of P18.1.12 = 1 and 2).
- P18.1.12 = „Digital Input (4)“
  - In case P3.56 „Deragging Enable“ is assigned to a digital input, deragging is activated by a rising edge of the signal at the respective terminal. The deragging will be performed according to the settings. When the signal is applied during normal operation, it is interrupted for the time of deragging. Another signal in addition to the rising edge, e.g. a start signal, is not necessary. Once deragging is activated, the signal can be removed.

P18.1.13 „Deragging Run Time“
This parameter defines the runtime in one direction during a derag cycle. It starts once the Derag Speed (P18.1.14) is reached. After expiration of this time the drive coast down to stand still. See also diagram above.

P18.1.14 „Derag Speed“
Output frequency of the drive in Hz during deragging.

P18.1.15 „Derag Off Delay“
Time in which the drive is at zero speed during a derag cycle, before it starts to reverse (see diagram above).

Parameter	Name	Range	Default
P3.56	Deragging Enable	DI = NormallyOpen (0) … DI…(…) … Virtual RO2 Function (35)	DI = NormallyOpen (0)
P18.1.11	Derag Cycles	0 … 10	3

Parame-ter	Name	Range	Default
P18.1.12	Derag at Start/Stop	- Off (0) - Start (1) - Stop (2) - Start and Stop (3) - Digital Input (4)	Aus (0)
P18.1.13	Deragging Run Time	0 … 3600 s	0 s
P18.1.14	Derag Speed	0 Hz … 60 Hz	5 Hz
P18.1.15	Derag Off Delay	1 … 600 s	10 s

3.3 Detection of fan belt break and dry run

This function is used to detect and to report an under load condition. In fan applications it is used to detect a break of the fan belt, in pump applications e.g. a dry run. In case the belt breaks or the pump runs dry, the motor load is reduced and the under load control reports it.

P18.6.1 „Pipe Fill Loss Detection Method“
Determines the source, which is used to detect an under load.

P18.6.2 „Pipe Fill Loss Level“
Determination of the threshold to detect an under load. The motor current is specified in Ampère, power and torque in percent. In case the threshold is undercut for a time longer than the one defined with P18.6.3 the drive responds as specified with P18.6.5.

P18.6.3 „Pipe Fill Loss Time“
When the threshold, defined with P18.6.2, is undercut for this time, the drive responds as specified with P18.6.5.

P18.6.4 „Pipe Fill Loss Frequency“
The response, defined with P18.6.5, only takes place at frequencies above the one, which is specified with P18.6.4.

P18.6.5 „Pipe Fill Loss Response“

- P18.6.5 = „No Action (0)“
  - No reaction in case the threshold, defined with P18.6.2 is undercut.
- P18.6.5 = „Warning (1)“
  - When the drive runs below the threshold, defined with P18.6.2, for a time, defined with P18.6.3, a warning message appears.
    - On the display „Pipe Fill Loss“ is indicated and the red LED “MS” flashes.
    - A relay contact closes, when it is assigned to “Warning (5)”.
- P18.6.5 = „Fault (2)“
  - When the drive runs below the threshold, defined with P18.6.2, for a time, defined with P18.6.3, a fault message is generated.
    - On the display „Pipe Fill Loss“ is indicated and the red LED “MS” flashes.
    - The variable frequency drive will be disabled.
    - The variable frequency drive attempts to start. The maximum number of attempts is defined with P18.6.6.

- After the final useless restart a relay contact closes, in case it is assigned to "Fault (3)" respectively opens when it is assigned to "Fault Invert (4)".

P18.6.6 „Pipe Fill Loss Attempts"

- Maximum number of attempts to restart the drive after a fault, when P18.6.5 is set to „Fault (2)".

Parame-ter	Name	Range	Default
P18.6.1	Pipe Fill Loss Detection Method	- Motor Current (0) - Motor Power (1) - Motor Torque (2)	Motor Current (0)
P18.6.2	Pipe Fill Loss Level	0.0 … 1000.0	0.0
P18.6.3	Pipe Fill Loss Time	0 … 600 s	0 s
P18.6.4	Pipe Fill Loss Frequency	0.00 … 60.00 Hz	0.00 Hz
P18.6.5	Pipe Fill Loss Response	- No Action (0) - Warning (1) - Fault (2)	No Action (0)
P18.6.6	Pipe Fill Loss Attempts	0 … 10	1

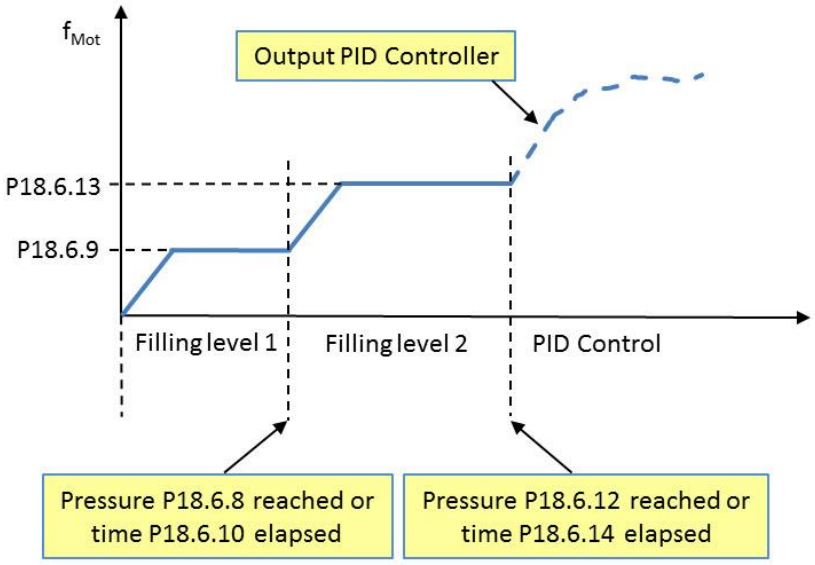
3.4 Pipe fill at start

In many pump systems the internal PID controller is used to control the system pressure. Before starting the pump, the system is nonpressurized and the difference between the required pressure and the one inside the system at that point of time is big. Would one enable the PID controller at the very beginning, the drive would react immediately and the system responds with a water hammer, which stresses the pipe system very much mechanically. The function "Pipe Fill" is used to prevent this.

The pressurization is performed with a low pump speed in up to two steps. Only when a certain pressure is reached, the output signal of the PID controller is used as a speed reference for the pump motor. In case the required pressure will not be reached, one can think about a leakage inside the system and a signal is generated.

During the pipe fill process „Prime Pump Active" is displayed on the keypad. In case a digital output is configured accordingly (Prime Pump Active (57)), a digital output is active during that period of time respectively a relay contact is closed. It opens when the pipe filling is finished.

The pipe fill function can only be used, when the speed reference is coming from the output of the PID controller (P1.14 or P1.15 or P7.2 = PID1 Control Output (17) or PID2 Control Output (18)).



P18.6.7 „Prime Pump Enable“
This parameter enables pipe filling at start.

- P18.6.7 = „DigIN:NormallyOpen (0)“
  - Pipe filling is disabled. At start the output of the PID controller provides the speed reference.
- P18.6.7 = „DigIN:NormallyClose (1)“
  - Pipe filling is enabled in general. It is performed at each start.
- P18.6.7 = „DigIN… (…)“
  - A HIGH signal at digital input DI… enables the function pipe filling. The signal has to be applied to the input at start already, otherwise pipe filling is not performed and the motor ramps to the speed according the reference, coming from the PID controller output. In case the signal is removed during pipe filling, the motor ramps to the speed according to the output of the PID controller immediately.

P18.6.8 „Prime Pump Level“
Pressure threshold to switch to the next level. Reference value is the feedback of the control variable. When the threshold is reached, the speed reference switches to the next level (Level 2 with P18.6.12 > 0 or PID with P18.6.12 = 0).

P18.6.9 „Prime Pump Frequency“
Output frequency of the variable frequency drive during pipe filling level 1.

P18.6.10 „Prime Pump Delay Time“
Normally a changeover between filling level 1 and the next level takes place, when the prime pump level, defined with P18.6.8, is reached. In case this value is not reached in a time defined with P18.6.10, a changeover is done after this time is elapsed.

P18.6.11 „Prime Pump Loss of Prime Level“
This parameter is effective during “Filling level 1”. In case the value defined here (in pump applications mostly the pressure) is undercut for a time defined with P18.6.3, the drive responds according to the setting of P18.6.5. If the pressure level is not reached in the specified time, the reason is quite often a leakage inside the tube system. The fault message highlights this. The keypad displays “Pipe Fill Loss”.

P18.6.12 „Prime Pump Level 2“
Pressure threshold to switch to the next level. Reference value is the feedback of the control variable. When the threshold is reached, the speed reference switches to the next level. P18.6.12 = 0 disables Level 2. The speed changes directly from the speed during filling level 1 to the output of the PID controller without passing level 2.

P18.6.13 „Prime Pump Frequency 2“
Output frequency of the variable frequency drive during pipe filling level 2. The value of P18.6.13 can also be smaller than the one of P18.6.9.

P18.6.14 „Prime Pump Delay Time 2“
Normally a changeover between filling level 2 and the output of the PID controller takes place, when the prime pump level, defined with P18.6.12, is reached. In case this value is not reached in a time defined with P18.6.14, a changeover is done after this time is elapsed.

P18.6.15 „Prime Pump Loss of Prime Level 2“
This parameter is effective during “Filling level 2”. In case the value defined here (in pump applications mostly the pressure) is undercut for a time defined with P18.6.3, the drive responds according to the setting of P18.6.5. If the pressure level is not reached in the specified time, the reason is quite often a leakage inside the tube system. The fault message highlights this. “Pipe Fill Loss” is displayed.

P18.6.3 „Pipe Fill Loss Time“
When the threshold, defined with P18.6.11 respectively P18.6.15, is undercut for this time, the drive responds as specified with P18.6.5.

P18.6.5 „Pipe Fill Loss Response“

- P18.6.5 = „No Action (0)“
  - No reaction when the threshold, defined with P18.6.11 respectively P18.6.15 is undercut.
- P18.6.5 = „Warning (1)“
  - When the drive runs below the threshold, defined with P18.6.11 respectively P8.6.15, for a time, defined with P18.6.3, a warning message appears.
    - On the display „Pipe Fill Loss“ is indicated and the red LED “MS” flashes.
    - A relay contact closes, when it is assigned to “Warning (5)”.
- P18.6.5 = „Fault (2)“
  - When the drive runs below the threshold, defined with P18.6.11 respectively P8.6.15, for a time, defined with P18.6.3, a fault message is generated.
    - On the display „Pipe Fill Loss“ is indicated and the red LED “MS” flashes.
    - The variable frequency drive will be disabled.
    - The variable frequency drive attempts to start. The maximum number of attempts is defined with P18.6.6.
    - After the final useless restart a relay contact closes, in case it is assigned to “Fault (3)” respectively opens when it is assigned to “Fault Invert (4)”.

After the final useless restart a relay contact closes, in case it is assigned to “Fault (3)” respectively opens when it is assigned to “Fault Invert (4)”.

P18.6.6 „Pipe Fill Loss Attempts“

Maximum number of attempts to restart the drive after a fault, when P18.6.5 is set to „Fault (2)“.

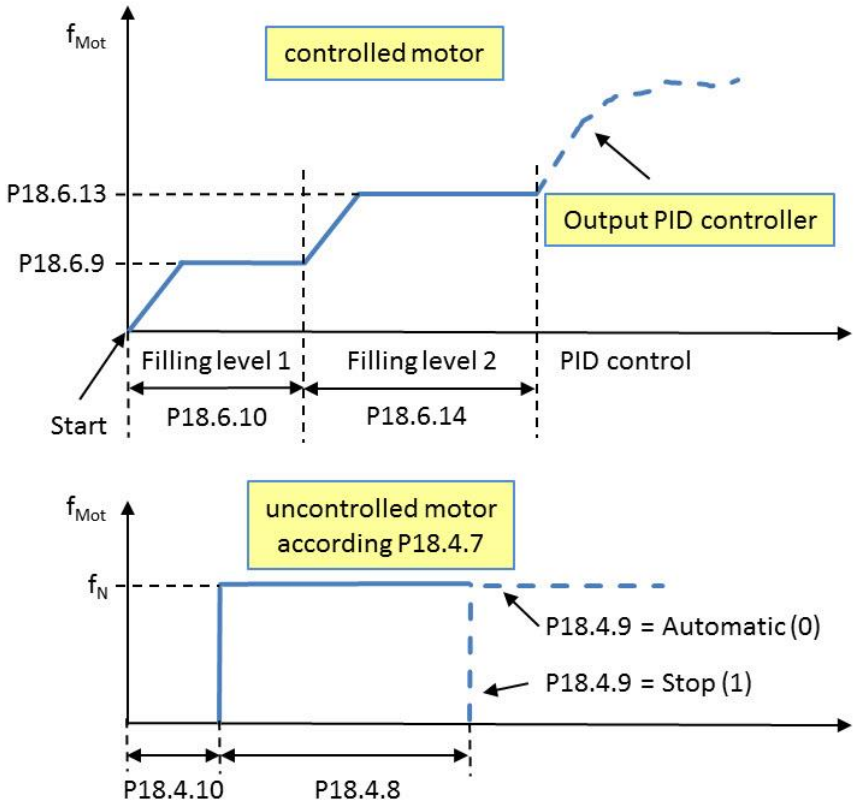
ATTENTION: At an automatic restart after a fault the function „pipe filling“ is not active! The output signal of the PID controller is effective immediately.

Parameter	Name	Range	Default
P5.1 or P5.2 or P5.3 or P5.4 or P5.5 or P5.6	DO1 Function RO1 Function RO2 Function RO3 Function Virtual RO1 Function Virtual RO2 Function	Not used (0) ..... Prime Pump Active (57) ..... Run Bypass/Drive (60)	…
P18.6.3	Pipe Fill Loss Time	0 … 600 s	0 s
P18.6.5	Pipe Fill Loss Response	- No Action (0) - Warning (1) - Fault (2)	No Action (0)
P18.6.6	Pipe Fill Loss Attempts	0 … 10	1
P18.6.7	Prime Pump Enable	DigIN:NormallyOpen (0) DigIN:NormallyClose (1) DigIN 1 (2) DigIN 2 (3) DigIN 3 (4) DigIN 4 (5) DigIN 5 (6) DigIN 6 (7) DigIN 7 (8) DigIN 8 (9) DigIN: A: IO1: 1 (10) (on DXG-EXT-3DI3DO1T) DigIN: A: IO1: 2 (11) (on DXG-EXT-3DI3DO1T) DigIN: A: IO1: 3 (12) (on DXG-EXT-3DI3DO1T) DigIN: A: IO5: 1 (13) (on DXG-EXT-6DI) DigIN: A: IO5: 2 (14) (on DXG-EXT-6DI) DigIN: A: IO5: 3 (15) (on DXG-EXT-6DI) DigIN: A: IO5: 4 (16) (on DXG-EXT-6DI) DigIN: A: IO5: 5 (17) (on DXG-EXT-6DI) DigIN: A: IO5: 6 (18) (on DXG-EXT-6DI) DigIN: B: IO1: 1 (19) (on DXG-EXT-3DI3DO1T) DigIN: B: IO1: 2 (20) (on DXG-EXT-3DI3DO1T) DigIN: B: IO1: 3 (21) (on DXG-EXT-3DI3DO1T) DigIN: B: IO5: 1 (22) (on DXG-EXT-6DI) DigIN: B: IO5: 2 (23) (on DXG-EXT-6DI) DigIN: B: IO5: 3 (24) (on DXG-EXT-6DI) DigIN: B: IO5: 4 (25) (on DXG-EXT-6DI) DigIN: B: IO5: 5 (26) (on DXG-EXT-6DI) DigIN: B: IO5: 6 (27) (on DXG-EXT-6DI) Time Channel 1 (28) Time Channel 2 (29) Time Channel 3 (30) RO1 Function (31) RO2 Function (32) RO3 Function (33)	DigIN:Normally Open (0)

Parameter	Name	Range	Default
		Virtual RO1 Function (34) Virtual RO2 Function (35)	
P18.6.8	Prime Pump Level	0.00 … 6000.00	0.00
P18.6.9	Prime Pump Frequency	0.00 … 60.00 Hz	0.00 Hz
P18.6.10	Prime Pump Delay Time	0.0 … 3600.0 min	0.0 min
P18.6.11	Prime Pump Loss of Prime Level	0.0 … 1000.0	0.0
P18.6.12	Prime Pump Level 2	0.00 … 6000.00	0.00
P18.6.13	Prime Pump Frequency 2	0.00 … 60.00 Hz	0.00 Hz
P18.6.14	Prime Pump Delay Time 2	0.0 … 3600.0 min	0.0 min
P18.6.15	Prime Pump Loss of Prime Level 2	0.0 … 1000.0	0.0

3.4.1 Activation of a single speed auxiliary motor

This function is only available in the operation mode P18.1.1 „Multi-pump Mode" = Single Drive Control (1). In addition to the possibilities described in 0 it is possible to support the filling procedure by adding a single speed pump to the system. The pipe fill function has to be activated with P18.4.7 by selecting the auxiliary motor which is added to the speed controlled one.



At start only the speed controlled motor is running. When the time set with P18.4.10 "Pipe Fill Aux Pump Delay" is elapsed, the single speed motor, selected by P18.4.7, is added. The following conditions have to be fulfilled, when setting the times:

$$P18.4.10 + P18.4.8 < P18.6.10 + P18.6.14$$

At which time the single speed motor is switched off depends on the setting of P18.4.9.

- P18.4.9 = Automatic (0)
  - The single speed motor remains on after the pipe filling procedure and is switched off at a time, where the system pressure is too high. See 4.1.2.
- P18.4.9 = Stop (1)
  - The single speed motor is switched off immediately, when the speed controlled motor quits the pipe filling procedure (see 0), but latest, when the time set with P18.4.8 is expired.

P18.4.7 „Pipe Fill Aux Pump Select“
Selection of the single speed motor, which is used as auxiliary motor during pipe filling. This motor is activated by an output relay of the variable frequency drive.

- Disabled (0)
- Aux Motor 1 (1) (Configuration of the output relay: „Motor 2 Control (44)“)
- Aux Motor 2 (2) (Configuration of the output relay: „Motor 3 Control (45)“)
- Aux Motor 3 (3) (Configuration of the output relay: „Motor 4 Control (46)“)
- Aux Motor 4 (4) (Configuration of the output relay: „Motor 5 Control (47)“)

P18.4.8 „Pipe Fill Aux Pump Run Time“
Maximum duration of pipe filling with a single speed motor.

P18.4.9 „Pipe Fill Aux Pump Operation“
Behavior of the single speed filling pump after the times set with P18.4.8 and P18.4.10.

- P18.4.9 = Automatic (0)
  - After expiration of P18.4.8 and P18.4.10 the filling pump continues to run..
- P18.4.9 = Stop (1)
  - After expiration of P18.4.8 and P18.4.10 the filling pump switches off.

P18.4.10 „Pipe Fill Aux Pump Delay“
Determination of the point in time when the single speed auxiliary motor is switched on.

Parame-ter	Name	Range	Default
P18.4.7	Pipe Fill Aux Pump Select	- Disabled (0) - Aux Motor 1 (1) - Aux Motor 2 (2) - Aux Motor 3 (3) - Aux Motor 4 (4)	Disabled (0)
P18.4.8	Pipe Fill Aux Pump Run Time	0.0 … 3600.0 min	0.0 min
P18.4.9	Pipe Fill Aux Pump Operation	- Automatic (0) - Stop (1)	Automatic (0)
P18.4.10	Pipe Fill Aux Pump Delay	0.0 … 600.0 min	2.0 min

4 Multi motor systems

The basic idea of a multi motor system in the field of pumps and fans is to reduce the system losses when running with part load. One starts the first motor and in case it is not possible to generate the required pressure or to extract the amount of flow, another motor is added to the system. This works in a similar way, when the demand decreases and a motor has to be taken out.

The logic control inside the variable frequency drives DG1 enables a tailored connection and disconnection as well as the consideration of additional aspects like equal run times of the different pumps respectively a high availability because of a concept for redundant operation.

4.1 Multi motor system with one speed controlled motor (P18.1.1 = 1)

Inside this system, which is mostly used in booster pump applications, multiple pumps exist, but only one of them is speed controlled. If required, additional pumps can be added with motor starters. These additional pumps work with single speed. The required logic is part of the variable frequency drive DG1 firmware.

The Multi-pump Mode (P18.1.1) must be set to “Single Drive Control (1)”. The following features are available

- Pressure regulation by using the internal PID controller. The output of this controller provides the speed reference for the speed controlled motor.
- 1 speed controlled motor inside the system
- Up to 4 single speed motors inside the system
- Connection and disconnection of the single speed motors via relay contacts of the variable frequency drive DG1, where the switching thresholds are adjustable (see 4.1.2).
- Pipe fill function to prevent water hammer (see 0)
- „Auto-Change“ function with the objective to have similar run times and therefore endurance for all pumps, not to have an outage of a pump because of wearing.

4.1.1 How it works

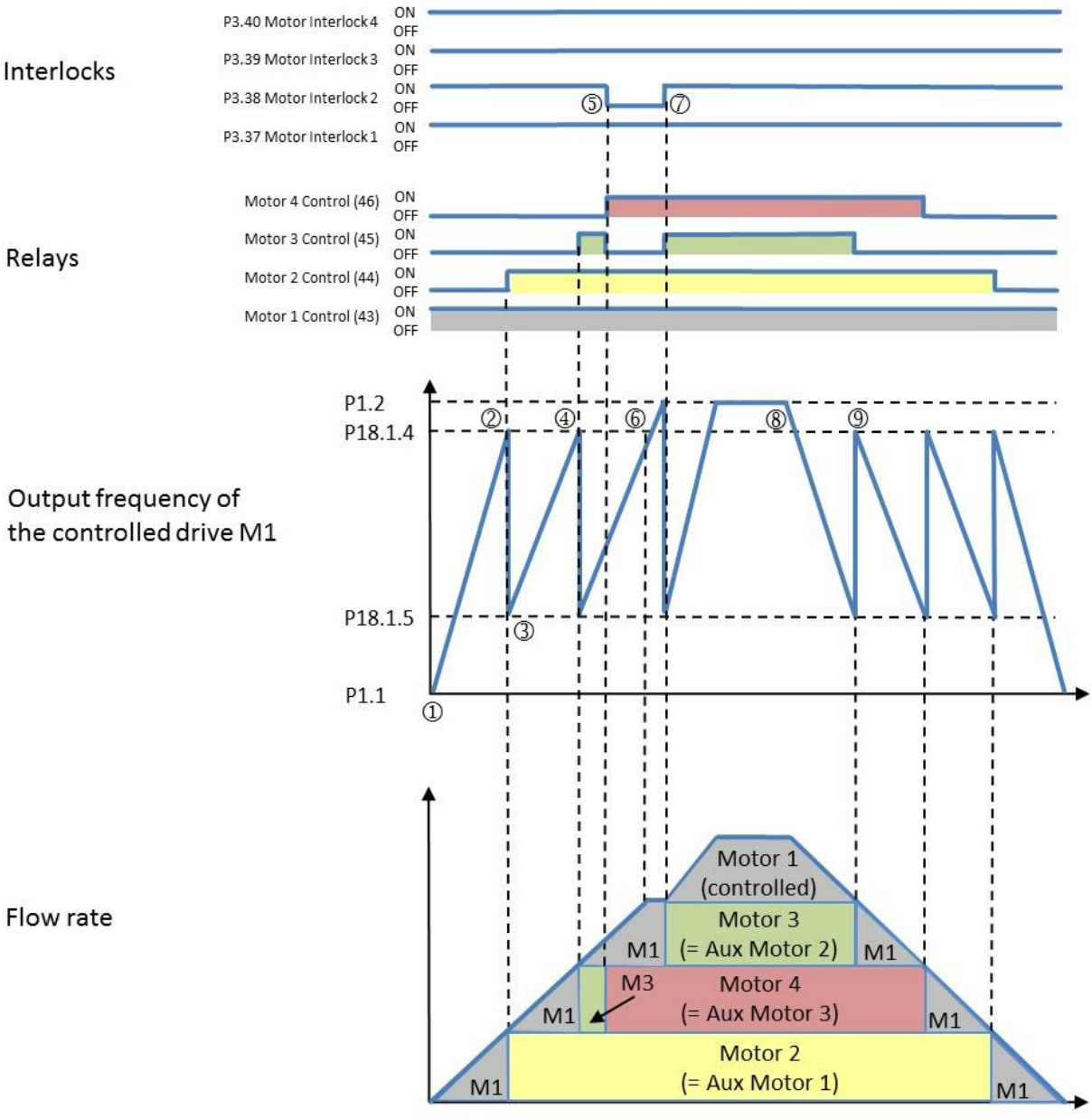
The diagram below describes the basic functionality of a multi motor system, consisting out of one speed controlled motor and multiple, in this example three, motors with single speed. The delay time (P18.1.6) at connection and disconnection is intentionally not taken into account. For a better readability, the thresholds and the maximum and minimum frequencies have been pulled apart. In practice the value for P18.1.4 will be close to P1.2 and the one for P18.1.5 close to P1.1, to prevent dead bands and overlapping in the PID control.

① The pump system is started. At the beginning, only the speed controlled motor 1 is running.
② When the staging frequency (P18.1.4) is reached, the single speed motor 2 starts.
③ The speed of motor 1 is reduced first, but increases again afterwards.
④ When the staging frequency (P18.1.4) is reached, the single speed motor 3 starts in addition and the speed of motor 1 is reduced again.
⑤ The external control signals an outage of motor 3 via the interlock signal. As motor 3 is no longer available, motor 4 will be started.
⑥ When reaching the staging frequency (P18.1.4) motor 3 is still not available. Motor 1 accelerates to the maximum frequency, set with f-max (P1.1). A further increasement of the flow is not possible at this point in time.

⑦ Motor 3 is available again and switched on in addition. The flow is increased further until its maximum.

⑧ A flow reduction is required. Motor 1 reduces its speed.

⑨ When the de-staging frequency (P18.1.5) is reached, motor 3 is disconnected and motor 1 accelerates to a higher speed. This procedure will be repeated until stand still or another point of operation.



Note:

The switching off procedure is working with the principle LI-FO (Last In – First Out).

4.1.2 Adding and removing pumps inside the system

When determining the connection and disconnection of additional pumps, the following elements play a role:

- the percental deviation of the feedback from the reference value
- the delay time before connection and disconnection
- the speed of the master motor respectively of the speed controlled motor in combination with single speed motors, at which motors are added to or removed from the system.

P18.1.3 „PID Bandwidth“
Deviation of the feedback from the reference value is percent (in default), above which a connection or disconnection of motors is possible. With calibrated PID Process Unit (P10.5 and P10.6), PID Bandwidth must be converted accordingly.

P18.1.4 „Staging Frequency“
Output frequency of the master drive, above which a connection of additional motors is possible. In addition the deviation between feedback and reference value must be greater than specified with P18.1.3 “PID Bandwidth” for the “Add/Remove Delay Time” (P18.1.6).

P18.1.5 „De-Staging Frequency“
Output frequency of the master drive, below which a disconnection of pumps is possible. In addition the deviation between feedback and reference value must be greater than specified with P18.1.3 “PID Bandwidth” for the “Add/Remove Delay Time” (P18.1.6).

P18.1.6 „Add/Remove Delay“
In case the deviation between feedback and reference value is out of the bandwidth and the output frequency is higher than P18.1.4 respectively lower than P18.1.5, the delay time set with P18.1.6 has to expire before another motor can be connected or disconnected.

P18.1.7 „Interlock Enable“
When trying to add pumps to a system it is important to know, if they are available. In case the Interlock function (P18.1.7) is enabled, the master gets information about the availability via digital inputs. In case the next motor is not available the next one is switched on etc. For this the digital inputs have to be configured with the parameters P3.37 … P3.41 (Motor Interlock 1 … 5) accordingly. Motor 1 is always the speed controlled one. In case P18.1.7 is disabled, the control of the other motors is done without this feedback signal.
HIGH signal at the respective inputs = the motor is available
LOW signal at the respective inputs = the motor is not available.

Note:
Depending on the number of necessary inputs respectively relay outputs the basic unit DG1 has to be extended with expansion modules.

- DXG-EXT-3RO → 3 relay outputs
- DXG-EXT-3DI3DO1T → 3 digital inputs, 3 digital outputs, 1 thermistor input
- DXG-EXT-6DI → 6 digital inputs

Parameter	Name	Range	Default
P3.37	Motor Interlock 1	DigIN:NormallyOpen (0) DigIN:NormallyClose (1) DigIN 1 (2) DigIN 2 (3) DigIN 3 (4) DigIN 4 (5) DigIN 5 (6) DigIN 6 (7) DigIN 7 (8) DigIN 8 (9) DigIN: A: IO1: 1 (10) (on DXG-EXT-3DI3DO1T) DigIN: A: IO1: 2 (11) (on DXG-EXT-3DI3DO1T) DigIN: A: IO1: 3 (12) (on DXG-EXT-3DI3DO1T) DigIN: A: IO5: 1 (13) (on DXG-EXT-6DI) DigIN: A: IO5: 2 (14) (on DXG-EXT-6DI) DigIN: A: IO5: 3 (15) (on DXG-EXT-6DI) DigIN: A: IO5: 4 (16) (on DXG-EXT-6DI) DigIN: A: IO5: 5 (17) (on DXG-EXT-6DI) DigIN: A: IO5: 6 (18) (on DXG-EXT-6DI) DigIN: B: IO1: 1 (19) (on DXG-EXT-3DI3DO1T) DigIN: B: IO1: 2 (20) (on DXG-EXT-3DI3DO1T) DigIN: B: IO1: 3 (21) (on DXG-EXT-3DI3DO1T) DigIN: B: IO5: 1 (22) (on DXG-EXT-6DI) DigIN: B: IO5: 2 (23) (on DXG-EXT-6DI) DigIN: B: IO5: 3 (24) (on DXG-EXT-6DI) DigIN: B: IO5: 4 (25) (on DXG-EXT-6DI) DigIN: B: IO5: 5 (26) (on DXG-EXT-6DI) DigIN: B: IO5: 6 (27) (on DXG-EXT-6DI) Time Channel 1 (28) Time Channel 2 (29) Time Channel 3 (30) RO1 Function (31) RO2 Function (32) RO3 Function (33) Virtual RO1 Function (34) Virtual RO2 Function (35)	DigIN:Normally Open (0)
P3.38	Motor Interlock 2	like P3.37	like P3.37
P3.39	Motor Interlock 3	like P3.37	like P3.37
P3.40	Motor Interlock 4	like P3.37	like P3.37
P3.41	Motor Interlock 5	like P3.37	like P3.37
P18.1.3	PID Bandwidth	0 …. 6000 %	10 %
P18.1.4	Staging Frequency	0 … 400 Hz	50 Hz
P18.1.5	De-Staging Frequency	0 … 50 Hz	0 Hz
P18.1.6	Add/Remove Delay	0 … 3600 s	10 s
P18.1.7	Interlock Enable	- Disabled (0) - Enabled (1)	Disabled (0)

4.1.3 Configuration

During configuration, the following points are determined:

- number of pumps inside the system
- configuration of the output relays to control the motor starters
- thresholds to connect / disconnect the single speed motors (see 4.1.2)
- configuration of the interlock inputs of the available starters in the system (see 4.1.2)
- optional: configuration of the function „Pipe fill“ (see 0)
- optional: configuration of the auto-change function (see 4.1.6)

P18.4.1 „Number of Pumps“
Number of pumps inside the system (speed controlled + single speed)

P5.2 „RO1 Function“ … P5.4 „RO3 Function“ on the basic unit and BX.2.1 „RO1 Function“ … BX.2.3 „RO3 Function on the expansion module DXG-EXT-3RO
The single speed pumps are controlled by relay contacts of the variable frequency drive DG1. They must be configured accordingly. It has to be noted, that motor 1 is always the speed controlled one. In a system without auto change a relay control for motor 1 is not needed. The basic unit DG1 has 3 output relays RO1 … RO3. Depending on the size of the pump system the number of relay outputs has to be increased by using the expansion board DXG-EXT-3RO.

- Control of motor 1 → Selection „Motor 1 Control (43)“
- Control of motor 2 → Selection „Motor 2 Control (44)“
- Control of motor 3 → Selection „Motor 3 Control (45)“
- Control of motor 4 → Selection „Motor 4 Control (46)“
- Control of motor 5 → Selection „Motor 5 Control (47)“

	Parameter	Name	Range	Default
Basic unit DG1	P18.4.1	Number of Pumps	1 … 5	1
	P5.2	RO1 Function	Not used (0) ..... Motor 1 Control (43) Motor 2 Control (44) Motor 3 Control (45) Motor 4 Control (46) Motor 5 Control (47) ..... Run Bypass/Drive	…
	P5.3	RO2 Function	like P5.2	…
	P5.4	RO3 Function	like P5.2	…
DXG-EXT-3RO	BX.2.1[1)]	RO1 Function	like P5.2	…
	BX.2.2	RO2 Function	like P5.2	…
	BX.2.3	RO3 Function	like P5.2	…

1) The letter „X“ inside the parameter name is used as wildcard. Instead of the letter a number appears on the display respectively in the parameter software, which depends on the slot, where the card is mounted.

4.1.4 Example with one speed controlled motor and one with fixed speed

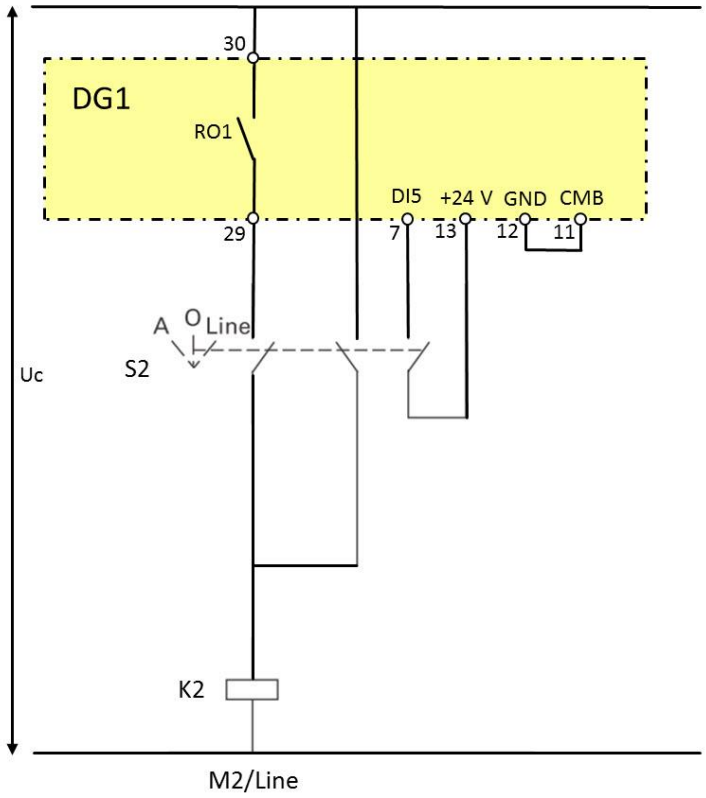
The system consists out of two pumps. One of them (M1) is speed controlled, the other one (M2) has a single speed. The protective devices F1 and F2 are used for short circuit protection. The motor protection for M1 is part of the variable frequency drive DG1, the one for the single speed motor is handled by the motor protection relay F2.1.

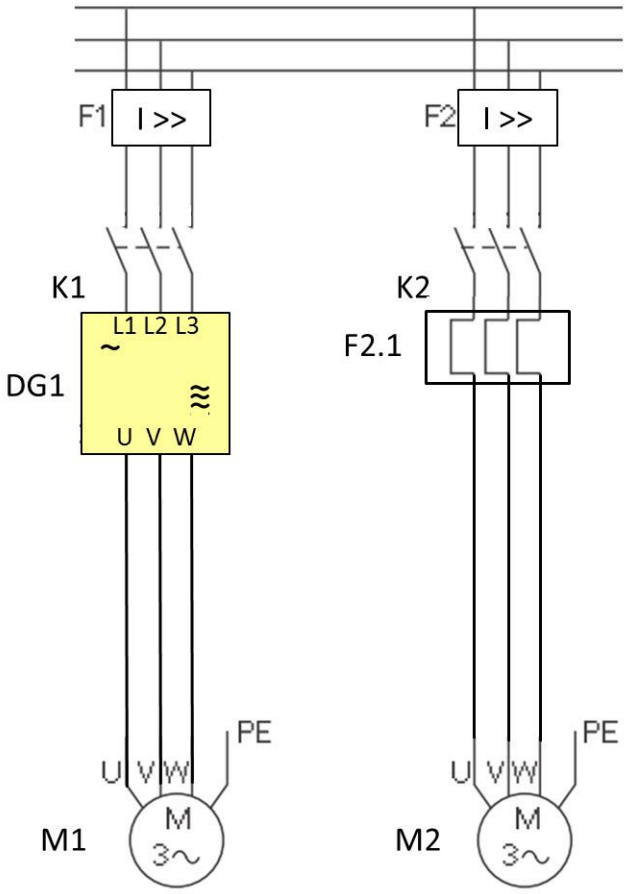
The selection switch has 3 positions. For operating in a multi pump system it has to be in position “A” (left). In position 0 the pump is switched off. In position “line” the pump M2 runs constantly with mains supply. In this case it is not controlled by the variable frequency drive.

The general settings, like e.g. maximum frequency …. are not listed inside this example as well as possible contactor interlocks on the control side (motor protection relay …).

Configuration DG1:

- P18.1.1 „Multi-pump Mode“ = Single Drive Control (1)
- P18.4.1 „Number of Pumps“ = 2
- Only motor 2 must be controlled by a contact of DG1. Therefore only one relay has to be configured accordingly, in this example: RO1.
    - P5.2 „RO1 Function“ = Motor 2 Control (44)
    - Now a contact between the terminals 29 and 30 is available, which closes, when motor 2 is required.
- It should be checked, if the motor starter is ready to run. In this example the information comes via digital input DigIN5 (terminal 7).
    - P18.1.7 „Interlock Enable“ = Enabled (1)
    - All pumps inside the system are checked concerning their availability, including the speed controlled pump 1, which doesn’t deliver this kind of information to a digital input.
        - P3.37 „Motor Interlock 1“ = DigIN:NormallyClose (1). Now an information about the status of pump 1 is given constantly.
        - P3.38 „Motor Interlock 2“ = DigIN: 5 (6). The signal common of DigIN 5 has to be connected with the signal common of the voltage source of the control signals. → Link from terminal 11 (CMB) to terminal 12 (GND). Now a ready signal will be present, when the selection switch is in position “A”.
- No auto change of pumps is required: P18.4.3 „Auto-Change Enable“ = Disabled (0)
- The setting of the ON and OFF thresholds must be done with P18.1.3 … P18.1.6 as described in chapter 4.1.2. It is recommended to set the staging frequency (P18.1.4) close to the rated frequency of the motor. The de-staging frequency (P18.1.5) should be accordingly low.


30
DG1
RO1
DI5
+24 V
GND
CMB
29
7
13
12
11
A
O
Line
S2
Uc
K2
M2/Line


F1
I >>
F2
I >>
K1
K2
L1 L2 L3
DG1
F2.1
U V W
PE
U V W
PE
M1
M
3~
M2
M
3~

4.1.5 Example with one speed controlled motor and two with fixed speed

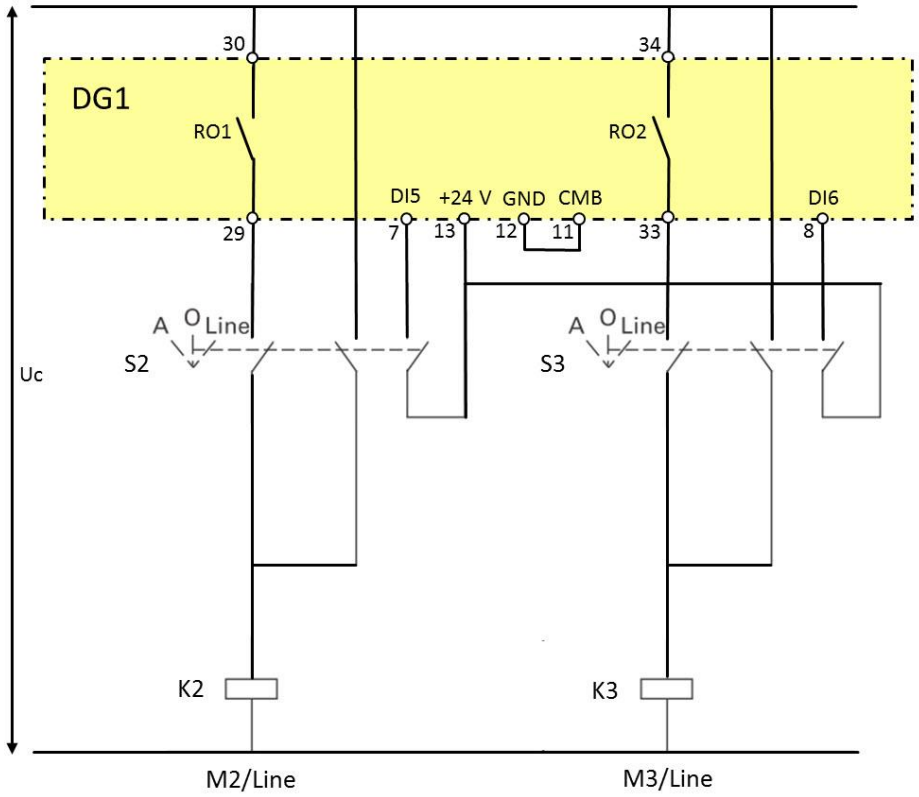
The system consists out of three pumps. One of them (M1) is speed controlled, the other ones (M2 and M3) have a single speed. The protective devices F1, F2 and F3 are used for short circuit protection. The motor protection for M1 is part of the variable frequency drive DG1, the one for the single speed motors is handled by the motor protection relays F2.1 and F3.1.

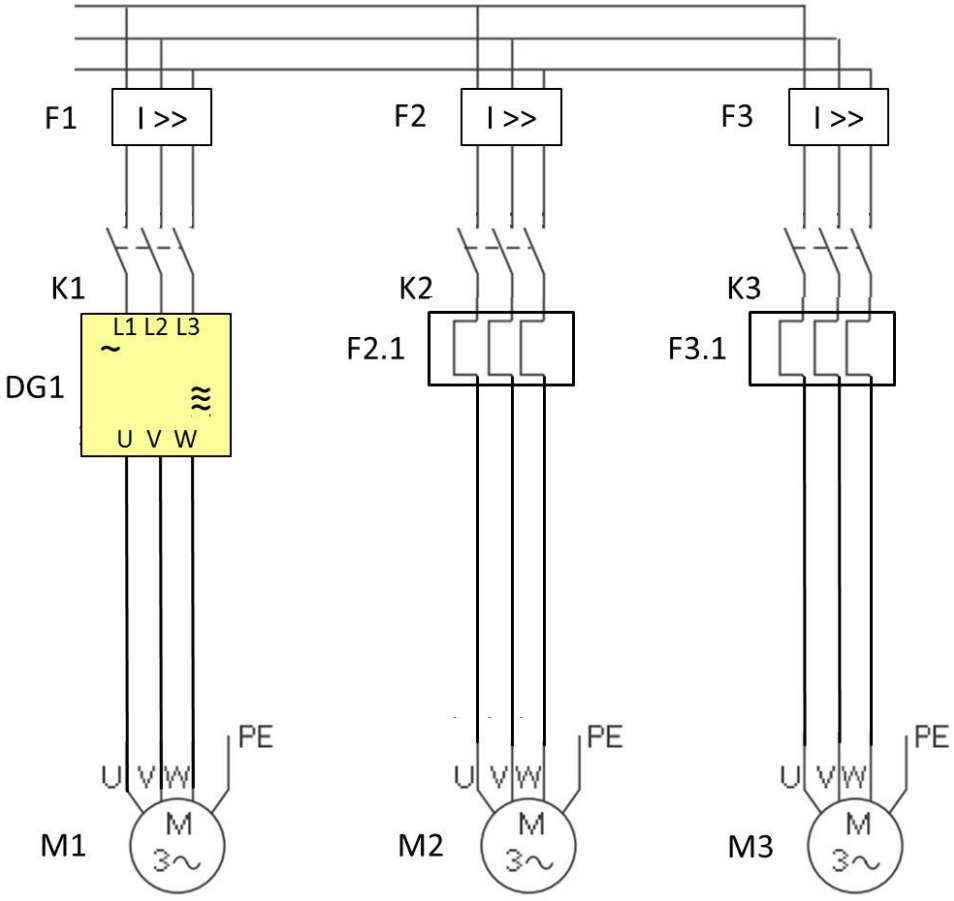
The selection switches have 3 positions. For operating in a multi pump system they have to be in position “A” (left). In position 0 the pumps are switched off. In position “line” the pumps M2 respectively M3 run constantly with mains supply. In this case they are not controlled by the variable frequency drive.

The general settings, like e.g. maximum frequency …. are not listed inside this example as well as possible contactor interlocks on the control side (motor protection relay …).

Configuration DG1:

- P18.1.1 „Multi-pump Mode“ = Single Drive Control (1)
- P18.4.1 „Number of Pumps“ = 3
- Only motors 2 and 3 must be controlled by a contact of DG1. Therefore only two relays have to be configured accordingly, in this example: RO1 and RO2.
    - P5.2 „RO1 Function“ = Motor 2 Control (44)
    - P5.3 “RO2 Function” = Motor 3 Control (45)
    - Now contacts between the terminals 29 and 30 (RO1) as well as 33 and 34 (RO2) are available, which close when motors 2 and 3 are required.
- It should be checked, if the motor starter is ready to run. In this example the information comes via the digital inputs DigIN5 (terminal 7) and DigIN6 (Terminal 8).
    - P18.1.7 „Interlock Enable“ = Enabled (1)
    - All pumps inside the system are checked concerning their availability, including the speed controlled pump 1, which doesn’t deliver this kind of information to a digital input.
        - P3.37 „Motor Interlock 1“ = DigIN:NormallyClose (1). Now an information about the status of pump 1 is given constantly.
        - P3.38 „Motor Interlock 2“ = DigIN: 5 (6).
        - P3.39 “Motor Interlock 3” = DigIN: 6 (7)
        - The signal common of the digital inputs has to be connected with the signal common of the voltage source of the control signals. → Link from terminal 11 (CMB) to terminal 12 (GND). Now a ready signal will be present, when the selection switch is in position “A”.
- No auto change of pumps is required: P18.4.3 „Auto-Change Enable“ = Disabled (0)
- The setting of the ON and OFF thresholds must be done with P18.1.3 … P18.1.6 as described in chapter 4.1.2. It is recommended to set the staging frequency (P18.1.4) close to the rated frequency of the motor. The de-staging frequency (P18.1.5) should be accordingly low.


30
34
DG1
RO1
RO2
DI5
+24 V
GND
CMB
DI6
29
7
13
12
11
33
8
A
O
Line
S2
S3
Uc
K2
K3
M2/Line
M3/Line


F1
I >>
F2
I >>
F3
I >>
K1
K2
K3
L1 L2 L3
DG1
F2.1
F3.1
U V W
PE
U V W
M
3~
M1
M2
M3

4.1.6 Auto-change

Mechanical parts wear from time to time and the longer a pump is running, the earlier maintenance is necessary. If one refers this to the system described in the chapters 4.1 to 4.1.5, where pump 1 is always the one, which is started first and pumps 2…5 follow, one can easily realize, that pump 1 is probably the weakest part of the system. The function "Auto Change" enables to change the sequence in which the pumps are switched on and off, to achieve a more or less equal runtime for each pump in the system.

There is a possibility to decide, if the speed controlled pump 1 is included in the change or if only the sequence of pumps 2 to 5 is changed. Pros for both versions exist. If one only looks to the wear it makes sense to include pump 1 into the change and that also pumps 2 to 5 can be operated with variable speed. For doing this, a changeover in the motor circuit is necessary, which leads to an additional effort to install the system EMC compliant. For example the cables to all pumps must be shielded. In addition, a changeover in the motor circuit leads to an interruption of the cable shield at the same time, which has to be bonded properly, to ensure that the EMC emission limits are kept. It has to be decided on a case by case basis, which version is the best for the application.

P18.4.2 „Include Freq Converter"

- Disabled (0): A change only takes place between the single speed pumps.
- Enabled (1): The speed controlled pump is included into the change.

P18.4.3 „Auto-Change Enable"

The auto change of pumps is only possible in systems with ONE speed controlled pump (P18.1.1 = Single Drive Control (1)). With P18.4.3 = Enabled (1) auto change is enabled. The starting sequence is rotating between the pumps in the system.

P18.4.4 „Auto-Change Interval"

This parameter determines after which time a change takes place.

P18.4.5 „Auto-Change Freq Limit"

An auto change only takes place, when the time defined with P18.4.4 is expired and the speed of the controlled motor is below the value set with P18.4.5.

P18.4.6 „Auto-Change Pump Limit"

A change only takes place, when the number of single speed pumps is lower than the value set with P18.4.6.

Parameter	Name	Range	Default
P18.4.2	Include Freq Converter	Disabled (0) Enabled (1)	Enabled (1)
P18.4.3	Auto-Change Enable	Disabled (0) Enabled (1)	Disabled (0)
P18.4.4	Auto-Change Interval	0.0 … 3000.0 h	48.0 h
P18.4.5	Auto-Change Freq Limit	0.00 … 60.00 Hz	25 Hz
P18.4.6	Auto-Change Pump Limit	0 … 5	1

4.1.7 Example: auto change between two pumps

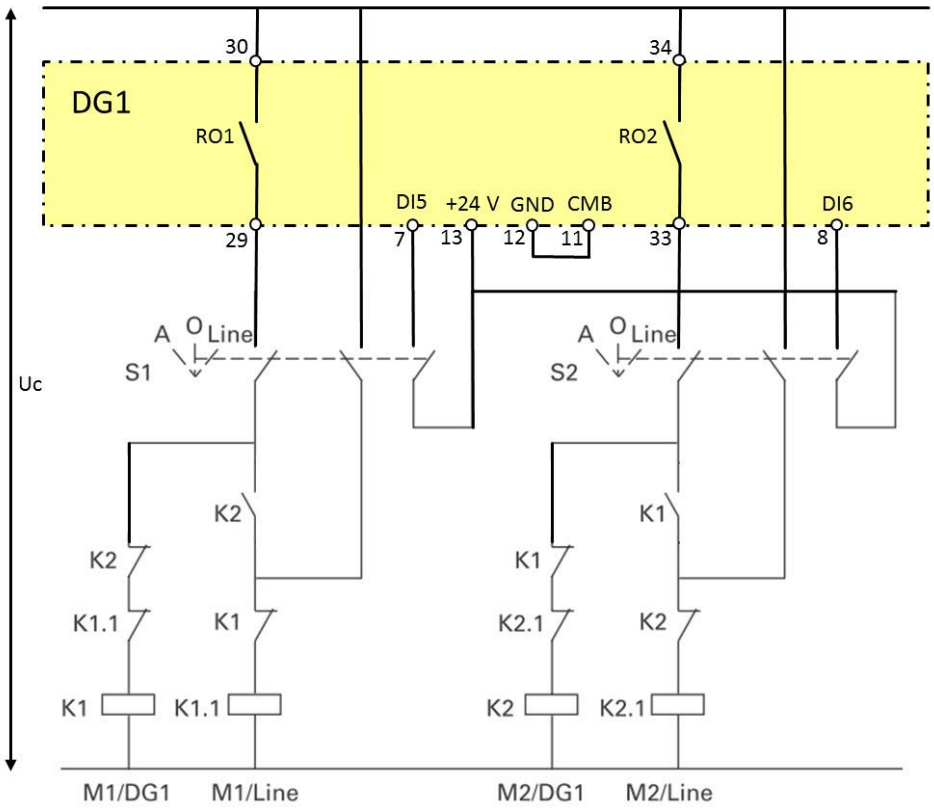
The system consists out of two pumps with an equal power rating. An auto change between the pumps should be performed to have equal run times → Each pump can be operated with variable speed as well as with a single speed. The protective devices F1 and F2 are used for short circuit protection when operated with a motor starter. FY is the short circuit protection for the variable frequency drive. Because of the changeover between the motors, each of them has to have its own motor protection relay F1.1 and F2.1.

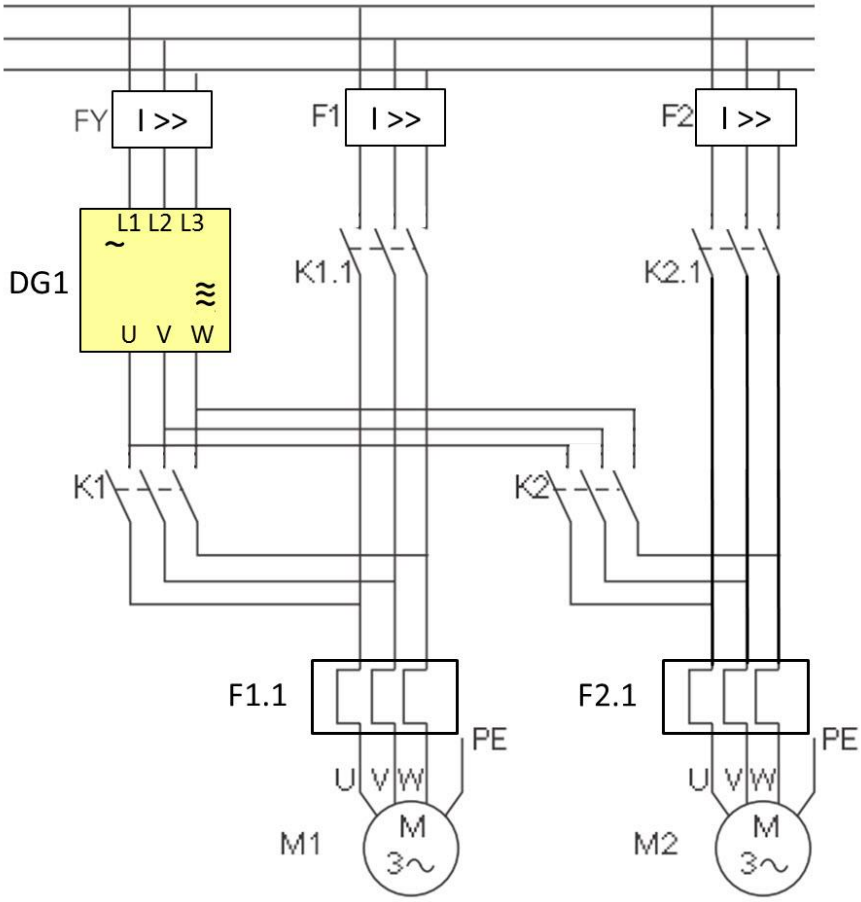
The selection switch has 3 positions. For operating in a multi pump system it has to be in position “A” (left). In position 0 the pump is switched off. In position “line” the pump M2 runs constantly with mains supply. In this case it is not controlled by the variable frequency drive.

The general settings, like e.g. maximum frequency …. are not listed inside this example as well as possible contactor interlocks on the control side (motor protection relay …). The motor cables must be shielded because of EMC requirements.

Configuration DG1:

- P18.1.1 „Multi-pump Mode“ = Single Drive Control (1)
- P18.4.1 „Number of Pumps“ = 2
- During single speed operation both motors are controlled by the device DG1. Therefore two relays have to be configured:
    - P5.2 „RO1 Function“ = Motor 1 Control (43). Now a contact between the terminals 29 and 30 is available, which closes, when motor 1 is required, controlled by a motor starter.
    - P5.3 „RO2 Function“ = Motor 2 Control (44). Now a contact between the terminals 33 and 34 is available, which closes, when motor 2 is required, controlled by a motor starter.
- It should be checked, if the motors are ready to run. In this example the information comes via the digital inputs DigIN5 (terminal 7) and DigIN6 (Terminal 8).
    - P18.1.7 „Interlock Enable“ = Enabled (1)
        - P3.37 „Motor Interlock 1“ = DigIN: 5 (6).
        - P3.38 „Motor Interlock 2“ = DigIN: 6 (7)
        - The signal common of the digital inputs has to be connected with the signal common of the voltage source of the control signals. → Link from terminal 11 (CMB) to terminal 12 (GND). Now a ready signal will be present, when the selection switch is in position “A”.
- An auto change shall be performed: P18.4.3 „Auto-Change Enable“ = Enabled (1)
- The speed controlled pump shall be included into the change: P18.4.2 = Enabled (1)
- Maximum number of pumps at the time of change: P18.4.6 = 2
- The setting of the ON and OFF thresholds must be done with P18.1.3 … P18.1.6 as described in chapter 4.1.2. It is recommended to set the staging frequency (P18.1.4) close to the rated frequency of the motor. The de-staging frequency (P18.1.5) should be accordingly low.


30
34
DG1
RO1
RO2
DI5
+24 V
GND
CMB
DI6
29
7
13
12
11
33
8
A
O
Line
S1
S2
Uc
K2
K1
K1.1
K2.1
M1/DG1
M1/Line
M2/DG1
M2/Line


FY
I >>
F1
F2
L1 L2 L3
DG1
U V W
K1.1
K2.1
K1
K2
F1.1
F2.1
PE
M1
M2
M
3~

4.1.8 Example: auto change between three pumps

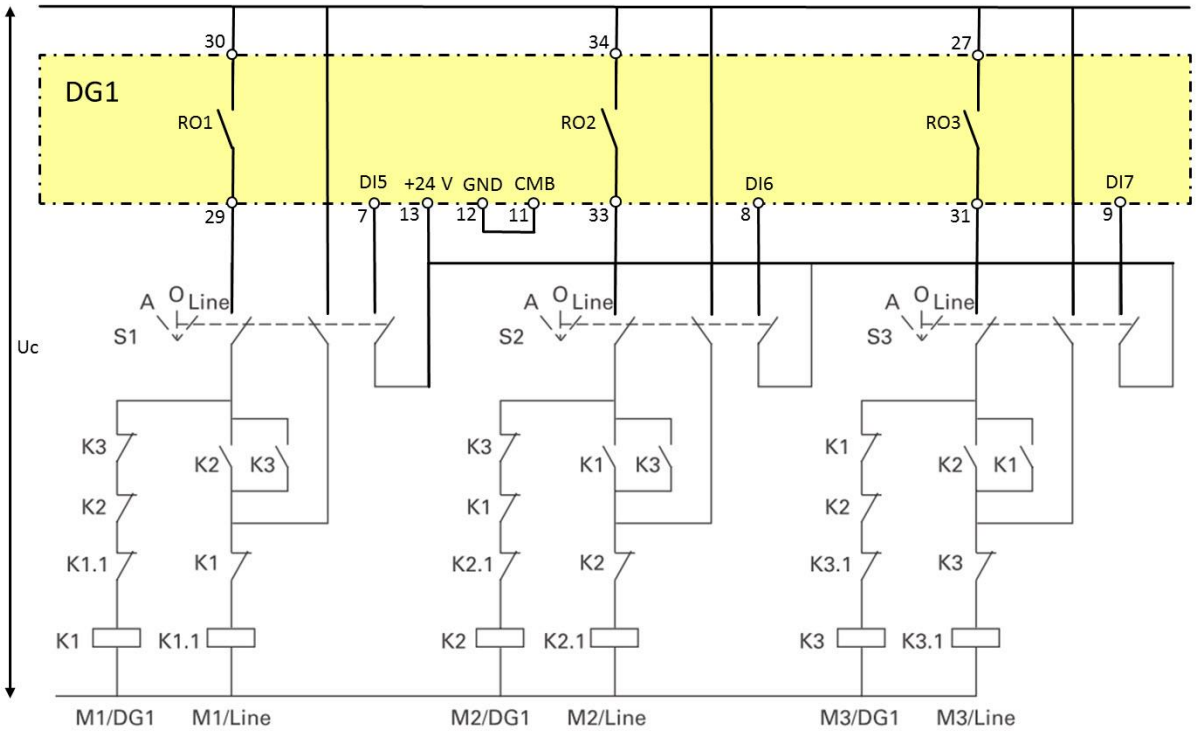
The system consists out of three pumps with an equal power rating. An auto change between the pumps should be performed to have equal run times → Each pump can be operated with variable speed as well as with a single speed. The protective devices F1, F2 and F3 are used for short circuit protection when operated with a motor starter. FY is the short circuit protection for the variable frequency drive. Because of the changeover between the motors, each of them has to have its own motor protection relay F1.1, F2.1 and F3.1.

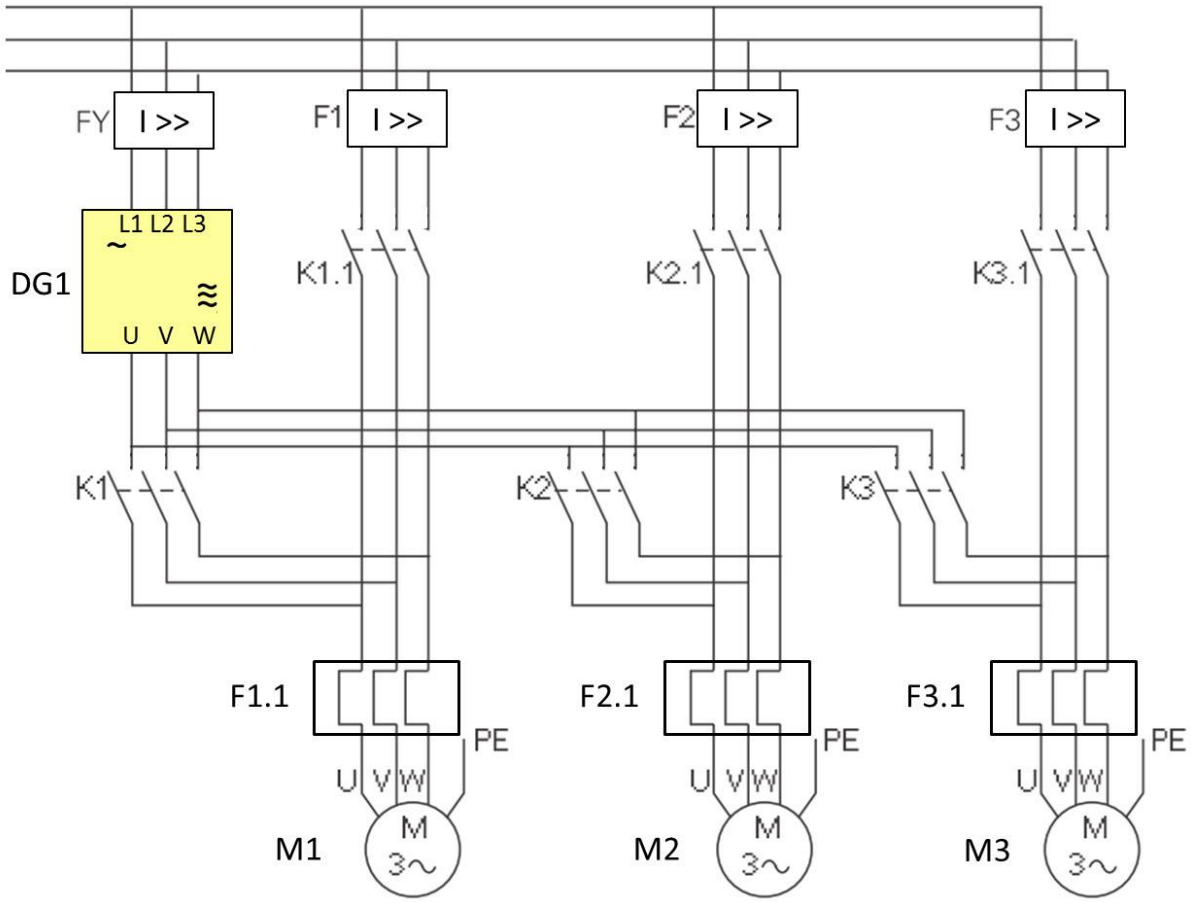
The selection switch has 3 positions. For operating in a multi pump system it has to be in position “A” (left). In position 0 the pump is switched off. In position “line” the pump M2 runs constantly with mains supply. In this case it is not controlled by the variable frequency drive.

The general settings, like e.g. maximum frequency …. are not listed inside this example as well as possible contactor interlocks on the control side (motor protection relay …). The motor cables must be shielded because of EMC requirements.

Configuration DG1:

- P18.1.1 „Multi-pump Mode“ = Single Drive Control (1)
- P18.4.1 „Number of Pumps“ = 3
- In case of single speed all three motors will be controlled by a contact of DG1. Therefore three relays have to be configured accordingly.
    - P5.2 „RO1 Function“ = Motor 1 Control (43)
    - P5.3 “RO2 Function” = Motor 2 Control (44)
    - P5.4 “RO3 Function” = Motor 3 Control (45)
    - Now contacts are available to control the single speed motors, which close when it is required.
- It should be checked, if the motor starter is ready to run. In this example the information comes via the digital inputs DigIN5 (terminal 7), DigIN6 (Terminal 8) and DigIN7 (Terminal 9).
    - P18.1.7 „Interlock Enable“ = Enabled (1)
    - All pumps inside the system are checked concerning their availability, including the speed controlled pump 1, which doesn’t deliver this kind of information to a digital input.
        - P3.37 „Motor Interlock 1“ = DigIN: 5 (6)
        - P3.38 „Motor Interlock 2“ = DigIN: 6 (7).
        - P3.39 “Motor Interlock 3” = DigIN: 7 (8)
        - The signal common of the digital inputs has to be connected with the signal common of the voltage source of the control signals. → Link from terminal 11 (CMB) to terminal 12 (GND). Now a ready signal will be present, when the selection switch is in position “A”.
- An auto change shall be performed: P18.4.3 „Auto-Change Enable“ = Enabled (1)
- The speed controlled pump shall be included into the change: P18.4.2 = Enabled (1)
- Maximum number of pumps at the time of change: P18.4.6 = 3
- The setting of the ON and OFF thresholds must be done with P18.1.3 … P18.1.6 as described in chapter 4.1.2. It is recommended to set the staging frequency (P18.1.4) close to the rated frequency of the motor. The de-staging frequency (P18.1.5) should be accordingly low.


DG1
30
34
27
RO1
RO2
RO3
DI5
+24 V
GND
CMB
DI6
DI7
29
7
13
12
11
33
8
31
9
Uc
A
O
Line
S1
S2
S3
K3
K2
K1.1
K1
K2.1
K3.1
M1/DG1
M1/Line
M2/DG1
M2/Line
M3/DG1
M3/Line


FY
I >>
F1
F2
F3
DG1
L1 L2 L3
U V W
K1.1
K2.1
K3.1
K1
K2
K3
F1.1
F2.1
F3.1
PE
M1
M2
M3
3~

4.2 Multi-Pump-Control (MPC) with multiple speed controlled pumps (P18.1.1 = 2)

In this system multiple pumps exist, which are all speed controlled. The variable frequency drives communicate via an RS485 bus connection. Enabling/Disabling signals and speed reference are given by the master drive. Because of availability reasons it is possible to have multiple master drives, but not at the same time. The required logic is included in the variable frequency drives DG1.

Multi-pump Mode (P18.1.1, P18.1.16) must be set to „Multi Drive Network (2)“. The following functions are available then:

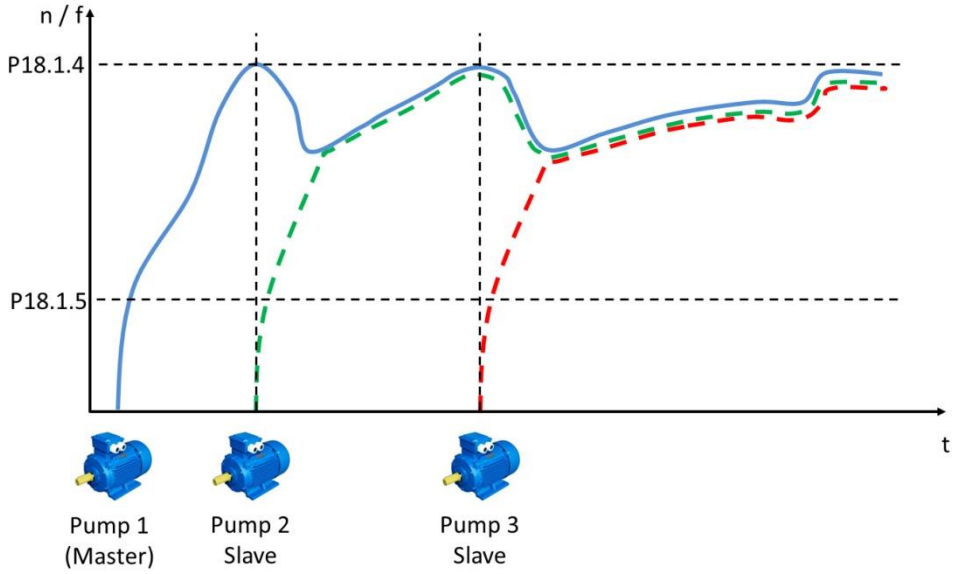
- Pressure control of the system with the internal PID controller. The PID controller’s output signal is the speed reference for all pumps of the system.
- up to 5 speed controlled motors inside the system
- Enabling / disabling of the slave drives by the master via bus connection
- Pipe fill to prevent water hammers (see 0)
- „Auto-Change“ function with the objective to have similar runtimes / endurance for all pumps to prevent a wear ahead of time.

4.2.1 How it works

The system consists out of a master drive and up to 4 slaves. The PID controller of the master controls the control variable, e.g. pressure. Its output signal is used as speed reference for all pumps inside the system. The communication between the drives is done via RS485 bus connection (see 0).

At start only the master drive works. Is the master’s power not sufficient to generate the required pressure, a slave is added. Is this still not sufficient, the next slave etc. . In case the pressure is too high, slaves are removed from the system in reverse sequence. In extreme cases it can happen, that the master drive changes into standby mode (Sleep / Wake up) and it only restarts, when a higher speed is required. Standby mode is only executed when only the master is still in operation. The conditions for connecting and disconnecting slaves are the same ones as described in chapter 4.1.2. When adding a slave, the slave drive will accelerate at the very beginning to catch up a motor, which may spin already. Afterwards it follows the speed reference, which is received from the master via bus.

The behavior of the master drive when a slave is added can be configured (see 4.2.1.8). It is for example possible, that all drives run with the same speed or that the master runs with a predefined fixed speed at the optimal operating point of the pump.



Behavior at addition of slaves

In systems with multiple possible master drives it can be configured, which drive acts as master (see 0). It is possible to select the drive with the lowest ID (P18.1.2) as the master or the one with the lowest run time to ensure an equal usage of the drives.

To operate a multi pump system with multiple speed controlled drives, the following signals are necessary:

	Drives, which can operate as master	Drives, which can operate as slave only
Bus	Yes	Yes
STO	Yes	Yes
Start	Yes	No
Run Enable (P3.9)	Optional	Optional
Reference	Yes	No
Feedback	Yes	No

Examples see 4.2.4

4.2.1.1 Behavior at communication loss with the master

At a communication loss with the master for more than 5 seconds, a new master is chosen out of the slaves automatically, as far as one is configured to be a master (see table under 4.2.1, column 2). This is always the drive with the lowest Drive ID at the bus (P18.1.2, see 0). The previous master drive still operates, but as an isolated drive. The new master drive now controls the other ones.

The new master must fulfill the following criteria:

- P18.5.2 „Regulation Source“ must be set to „PID Controller 1 (1)“.
- No fault message may be present.
- In case interlock is enabled (P18.1.7 “Interlock Enable” = “Enabled (1)”, see 4.1.2) the interlock signal must be applied. In a multi-drive system only the P3.37 "Motor Interlock 1" must be assigned to a digital input for each master.

- The variable frequency drive has the lowest drive-ID (P18.1.2)

In case no drive exists, which fulfills the criteria above, the setting of parameter P18.5.3 “Recovery Method” determines, if the drive still runs with the latest speed of if it stops.

When the communication with the original master drive recovers, all slaves will stop in case the original master is stopped or in standby mode.

It is recommended to assign the signal „Run Enable“ (P3.9) to a digital input of the slave drives, which must have a HIGH signal during normal operation. In this case it is possible to stop the slave drives individually. If separate operation of the drive is required (e.g. for maintenance purposes), a digital input must be assigned to parameter P3.58. This selects "Multi-Drive Mode 2" (P18.1.16 = Disable) with HIGH signal. Now this drive can be started and stopped separately from the system.

Parameter	Name	Range	Default
P18.5.2	Regulation Source	Network only (0) PID Controller 1 (1)	Network only (0)
P18.5.3	Recovery Method	Automatic (0) Stop (1)	Automatic (0)

4.2.1.2 System redundancy

The devices of the series Power XL DG1 support up to 5 drives in the network with one motor each. On the keypad of the master drive respectively the parameter software Power Xpert inControl the status of all drives inside the system can be displayed (see 4.2.5 and 4.2.6). The parameter P18.5.1 “Number of Drives” defines, how many drives of the system can be active simultaneously. In case there are 5 drives inside the system, but only two of them may run at the same time, P18.5.1 has to be set to “2”. The remaining 3 drives act as backup drives. They are used, when one of the active drives fails respectively when it is necessary because of the drives’ run time (as far as this function is enabled (see 0)).

Parameter	Name	Range	Default
P18.5.1	Number of Drives	1…5	1

4.2.1.3 Slave backup

In case a slave stops during operation without demand by the master, e.g. because of a fault or a missing interlock signal, the master will immediately activate another slave as far as available, without waiting until the reason for the trip is eliminated.

4.2.1.4 Behavior of the system at deactivation of a slave because of STO

There are applications, where the STO signals (Safety Torque OFF) of Master and Slaves are not linked together. With P18.5.4 “Callback Source” can be configured, if in case the STO signal is removed from the slave, only this slave is stopped (P18.5.4 = No Action (0)) or the complete system (P18.5.4 = Safety Torque Off (1)). Removing the STO signal from the master leads to a stop of the complete system.

Parameter	Name	Range	Default

P18.5.4	Callback Source	No Action (0) Safety Torque Off (1)	No Action (0)

4.2.1.5 Behavior at fire mode

The behavior at fire mode depends on which drive receives the respective fire mode signal. In this case the drive must be configured for fire mode (see Application Note AP040065EN). When the master receives the fire mode signal, all currently active drives accelerate to the respective speed. When a slave receives a fire mode signal it decouples itself from the system and runs as a single drive at the speed, which is defined for fire mode. The other drives continue to operate in the normal way. If the fire mode signal is removed from a slave, it automatically returns to the system.

If the fire mode signal is removed from a master, the whole system stops. For a restart the active master must have a new edge on the start command.

4.2.1.6 Stop button on the keypad

In default the stop button on the keypad is enabled (P7.5 “Keypad Stop” = “Always enabled (1)”). When the stop button of the master drive is pushed, the complete system stops. In case the stop button of a slave is pushed, only this certain slave stops and changes to the mode for single drives (P18.1.1 “Multi-pump Mode” = “Single Drive Control (1)”). This behavior is used to have the possibility to maintain, but the rest of the system continues to run. Another possibility for maintenance purposes is to use P18.1.16 “Multi-Pump Mode2” = “Disabled(0)”.

4.2.1.7 Run time monitoring

In default connection and disconnection of pumps depend on the drive ID, set with P18.1.2 (P18.5.5 = “Drive ID (0)”). Alternatively the selection can depend on the runtime up to this point in time, to operate the pumps inside the system equally. In this case P18.5.5 “Add/Remove Drive Selection” has to be set to “Run Time (1)”. Now the system starts with the drive with the lowest runtime and adds other drives according to the same criterion. When removing drives from the system, always the one with the highest run time is chosen.

The run time is only counted, when the respective counter is enabled with P18.5.6 „Run Time Enable”

In case the run time of a drive is above the value specified with P18.5.7 „Run Time Limit“, the message „Need alternation“ is displayed. With P18.5.7 = 0 this function is disabled.

Note:
M32 “PID1 Error Value” must be inside P18.1.3 “PID Bandwidth

The run time counter can be reset by selecting “Reset (1)” with P18.5.8. After a reset of the counter P18.5.8 is set back to “No Action (0)” automatically.

Parameter	Name	Range	Default

P18.5.5	Add/Remove Drive Selection	Drive ID (0) Run Time (1)	0
P18.5.6	Run Time Enable	Disabled (0) Enabled (1)	0
P18.5.7	Run Time Limit	0 … 300000 h	0 h
P18.5.8	Run Time Reset	No Action (0) Reset (1)	0

Note:
Before the drives are started, the start command must be present on all drives (e.g. DigIN 1). Otherwise slaves will not go over to master mode if start command is not present.
Drives can be connected to a central feedback signal (e.g. via fieldbus) or each to individual feedback signals too.

In case of running all drives and each drive is showing the message “Need Alternation” all drives keep running, if M32 “PID1 Error Value” is inside P18.1.3 “PID Bandwidth”. A change takes place when M32 “PID1 Error Value” becomes larger than P18.1.3 “PID Bandwidth” and thus the master drive switches off the slave drives (e.g. at minimum frequency). If in this case the master drive goes into sleep mode, a change takes place after automatic restart reaching the threshold P10.21 “PID1 Set Point 1 Wake Up Level”.

4.2.1.8 Behavior of the master at addition of a slave

The behavior of the master at addition of a slave can be configured with Parameter P18.5.9 „Master Drive Mode“. Not depending on this setting, the output signal of the master’s PID controller is used as speed reference for the slaves.

P18.5.9 „Master Drive Mode“

- Follow PID (0)
  - The master drive follows the signal at the output of its PID controller.
- Fixed Speed (1)
  - When adding a slave the master drive ramps to a fixed speed defined with P18.5.10 after the “Master Fixed Speed Delay” (P18.5.11) is expired. The pump can then be operated with the optimal speed in terms of energy efficiency. The output of the master’s PID controller is still used as speed reference for the slaves.
- Turn Off (2)
  - When adding a slave the master switches off, after the time, defined with P18.5.11, is expired.

P18.5.10 „Master Fixed Speed“

- Defines the frequency at which the master drive operates, when P18.5.9 = „Fixed Speed (1)“ is selected.

P18.5.11 „Master Fixed Speed Delay“

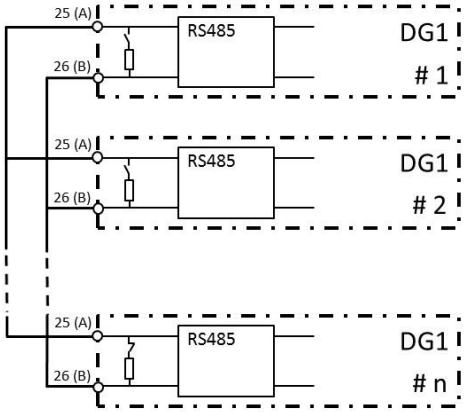
- After addition of a slave the time defined with this parameter has to expire before the master drive ramps to a fixed speed (P18.5.9 = Fixed Speed (1)) or is switched off (P18.5.9 = Turn Off (2)).

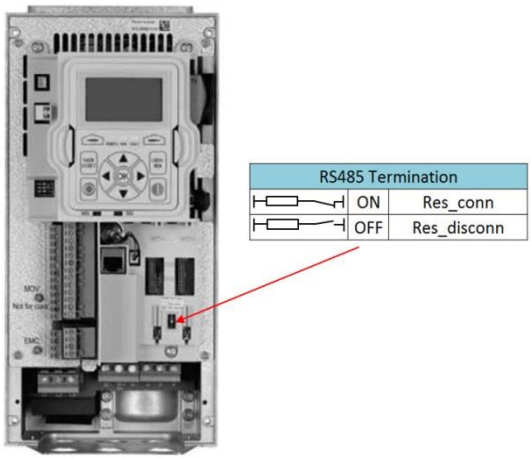
Parameter	Name	Range	Default

P18.5.9	Master Drive Mode	Follow PID (0) Fixed Speed (1) Turn Off (2)	0
P18.5.10	Master Fixed Speed	0,00 … 60,00 Hz	50,00 Hz
P18.5.11	Master Fixed Speed Delay	0 … 1000 s	5 s

4.2.2 Bus connection

The communication between the drives takes place via a serial link RS485. The addresses of the drives at the bus is set with P18.1.2 „Drive ID“.





The address has to be different from „0“. The setting “0” means, that this drive is not part of the multi pump system. This address also determines the sequence when adding pumps. The lowest address has priority when a master is determined (see also 0). In addition it is the reference when displaying the status (P18.2.xx) and Measurement (P18.3.xx), which is described below.

Note:
Group P18.2.xx is visible in each drive of the MPC system, P18.3.xx is only visible with the active master (keypad and Power Xpert inControl).

The terminals 25 (A) and 26 (B) of all drives inside the system have to be connected with twisted pair wires. At the physically last drive in the bus system the bus termination resistor has to be activated (DIP switch in position “Res_conn). At all other drives the termination resistor may not be connected (DIP switch in position “Res_disconn”).

Parameter	Name	Range	Default
P18.1.2	Drive ID	0 … 5	0
P20.3.2.2	RS485 Baud rate	9600 … 115200	19200

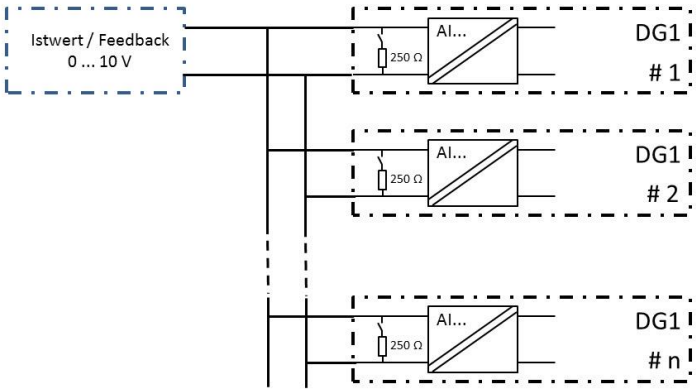
4.2.3 Connecting sensors

The control variable in a pump or fan system has to be fed back to the controller to operate properly. The feedback sensors have different signals like 0 … 10 V, 0 … 20 mA, 4 … 20 mA. The adaptation of the analog inputs to the different types of signals are described inside the Application Note AP040129EN “Configuration of the analog I/Os”.

In systems, where multiple drives can operate as a master, it is necessary to connect the feedback signal to each of these possible master drives.

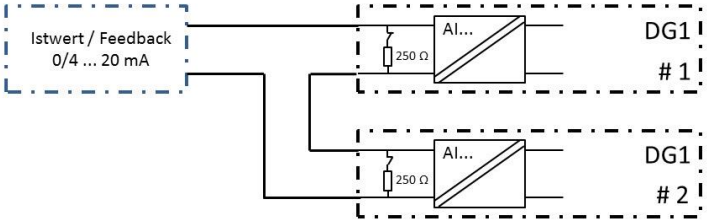
Feedback signal as voltage 0 … 10 V:

- The feedback signal is wired in parallel to all possible master drives.
- The analog input must be configured for a signal 0 … 10 V.



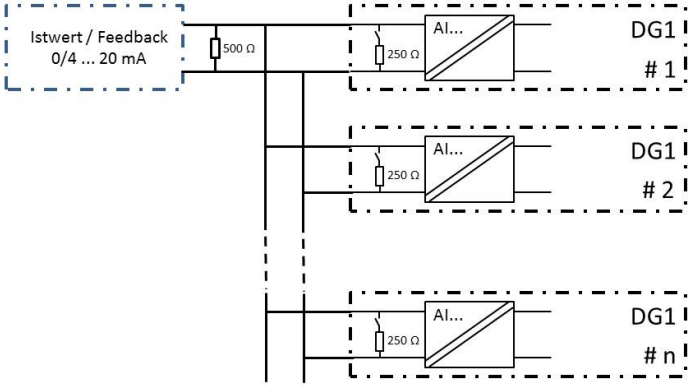
Feedback signal as current 0/4 … 20 mA. Maximum 2 drives

- The feedback signal is looped through both analog inputs, where 5 V are present at each analog input (20 mA · 250 Ω burden resistance). Because the maximum voltage at the output of a feedback sensor is 10 V, this solution can only be used in systems with up to two master drives.
- The analog input must be configured for a signal 0 … 20 mA respectively 4 … 20 mA.



Feedback signal as current 0/4 … 20 mA. Up to 5 drives

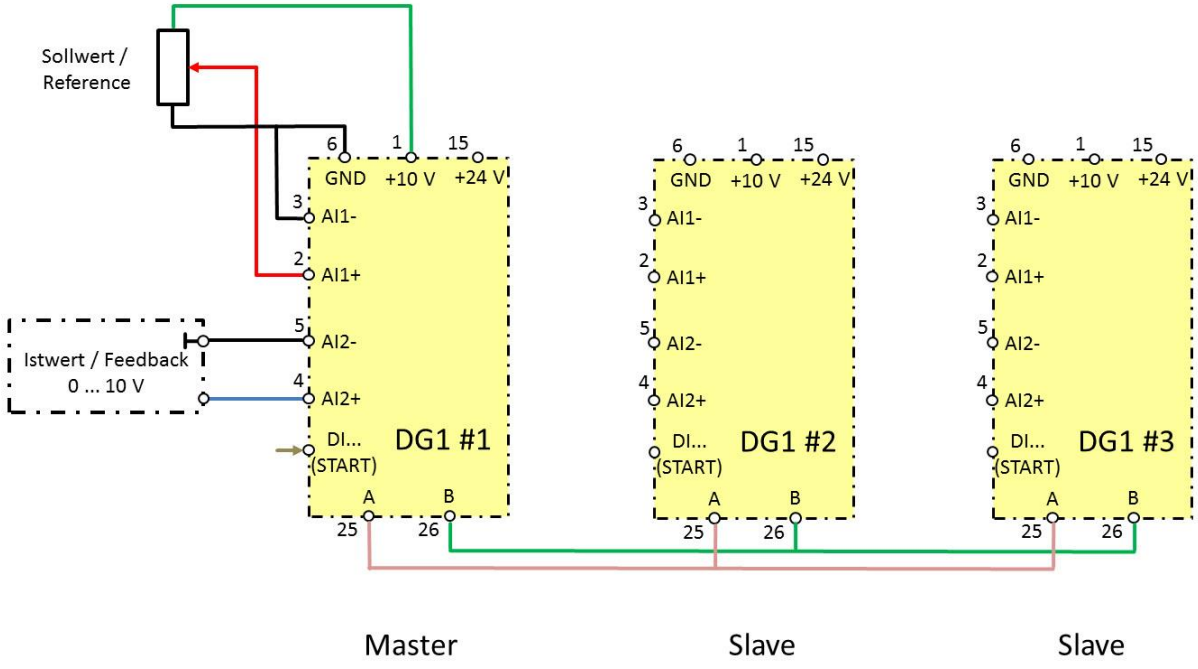
- A looping of the feedback signal through more than 2 drives is not possible (see above). Therefore the current signal is converted into a voltage one by means of an external burden resistor 500 Ω.
- This voltage signal is wired in parallel to all possible master drives.
- The analog input must be configured for a signal 0 … 10 V.



4.2.4 Configuration examples

4.2.4.1 Example 1: 1 master + 2 slaves

A pump system consists out of 3 speed controlled drives. Drive #1 is the master, the two others are slaves. A standby master is not foreseen. Before the system starts, the pipes inside the system shall be filled with water to prevent a water hammer at start. (1 filling level). The filling procedure shall be reported with relay RO3. The reference comes from a potentiometer as signal 0 … 10 V. The feedback value comes from a sensor 0 … 10 V. The variable frequency drive #3 is physically the last one at the bus.

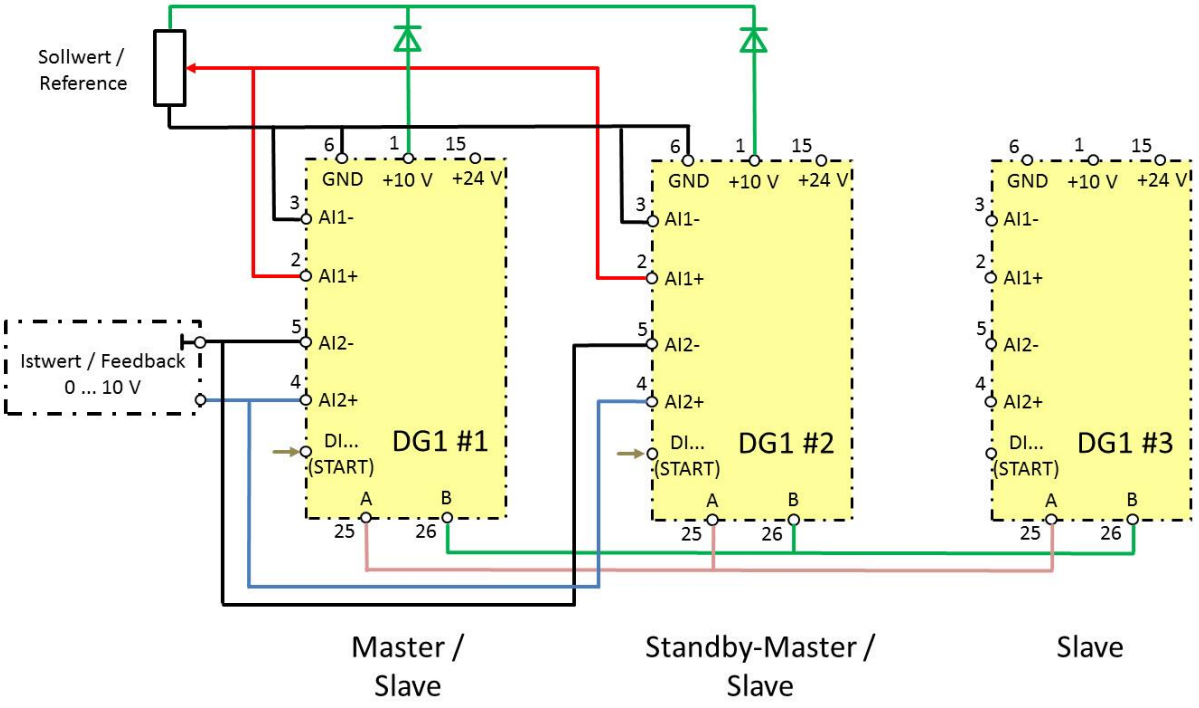


	DG1 #1 Master	DG1 #2 Slave	DG1 #3 Slave
Selection of the mode of operation			
Multi-pump Mode	P18.1.1 = Multi Drive Network (2)	P18.1.1 = Multi Drive Network (2)	P18.1.1 = Multi Drive Network (2)
Maximum No. of pumps, which run simultaneously	P18.5.1 = 3	P18.5.1 = 3	P18.5.1 = 3
Bus			
Control	The master drive controls the slaves via the bus. The terminals 25 (A) and 26 (B) of all drives involved, must be connected in parallel.		
DIP switch „RS485 Termination“	Res_disconn	Res_disconn	Res_conn
Drive ID	P18.1.2 = 1	P18.1.2 = 2	P18.1.2 = 3
RS485 Baud rate (must be equal at all drives)	P20.3.2.2 = 38400 (2)	P20.3.2.2 = 38400 (2)	P20.3.2.2 = 38400 (2)
Start			
	Starts the system with a „start“ command applied to a digital input.	Both slaves receive the start and stop command via bus. They can be switched off separately with the signal “Run Enable (P3.9) assigned to a terminal. If this command is re-moved, the drive stops.	

	DG1 #1 Master	DG1 #2 Slave	DG1 #3 Slave
Reference value			
	Signal 0 … 10 V via potentiometer, which is supplied by the internal voltage of DG1. Analog input AI1 is used. The analog input and the PID controller must be configured accordingly. The signal commons of the supply voltage (GND, terminal 6) and the analog input (AI1-, terminal 3) must be linked.	Not necessary	
Source for speed reference	PID1 Control Output (17)	Not necessary	
Regulation Source	PID Controller 1 (1)	Network only (0)	Network only (0)
Feedback			
	Signal 0 … 10 V from an external sensor. Analog input AI2 is used. The analog input and the PID controller must be configured accordingly. The signal commons of the external sensor and the analog input (AI2-, terminal 5) must be linked.	Not necessary	
Pipe filling			
Enabling	P18.6.7 = DigIN: Normally Close (1)	Not necessary	
Settings level 1	P18.6.8 up to P18.6.11 Application dependent		
Disable level 2	P18.6.12 = 0		
Reporting	P5.4 = Prime Pump Active (57)		
Adding pumps to and removing them from the system			
Frequency when adding	P18.1.4	Not necessary	
Frequency when removing	P18.1.5		
Band width	P18.1.3		
Delay time	P18.1.6		

4.2.4.2 Example 2: 2 masters + 1 slave

A pump system consists out of 3 speed controlled drives. Drive #1 is the master, the two others are slaves. Drive #2 is a standby master, which is activated, when drive #1 cannot work any longer and must be exchanged. In this situation the system shall continue to run. Before the system starts, the pipes inside the system shall be filled with water to prevent a water hammer at start (2 filling levels). The filling procedure shall be reported with relay RO1. The reference comes from a potentiometer as signal 0 … 10 V. The feedback value comes from a sensor 0 … 10 V. The variable frequency drive #3 is physically the last one at the bus.



Reference and feedback value must be applied to the master as well as to the standby master. Because the system has to run, even when exchanging the original master, the supply for the reference must be maintained. Therefore the 10 V supplies of drive #1 and #2 are wired in parallel. Backup diodes must be used.

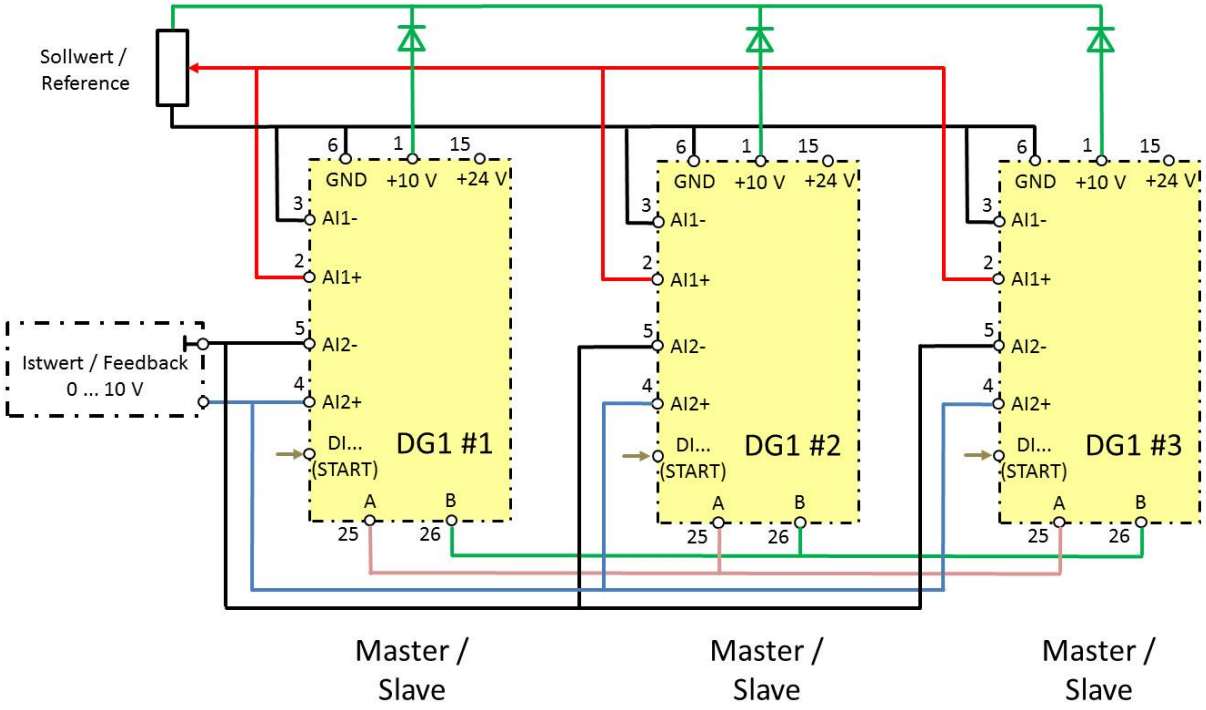
Practice tip: Because the drives #1 and #2 are configured identically except the drive ID, it is recommended to configure the drive #1 completely first and to copy the parameter set afterwards to drive #2. At the end, the drive ID of drive #2 (P18.1.2) must be changed to a value different from drive #1.

	DG1 #1 Master	DG1 #2 Slave + Standby-Master	DG1 #3 Slave
Selection of the mode of operation			
Multi-pump Mode	P18.1.1 = Multi Drive Network (2)	P18.1.1 = Multi Drive Network (2)	P18.1.1 = Multi Drive Network (2)
Maximum No. of pumps, which run simultaneously	P18.5.1 = 3	P18.5.1 = 3	P18.5.1 = 3
Bus			
Control	The master drive controls the slaves via the bus. The terminals 25 (A) and 26 (B) of all drives involved, must be connected in parallel.		
DIP switch „RS485 Termination“	Res_disconn	Res_disconn	Res_conn
Drive ID	P18.1.2 = 1	P18.1.2 = 2	P18.1.2 = 3
RS485 Baud rate (must be equal at all drives)	P20.3.2.2 = 38400 (2)	P20.3.2.2 = 38400 (2)	P20.3.2.2 = 38400 (2)

	DG1 #1 Master	DG1 #2 Slave + Standby-Master	DG1 #3 Slave
Start			
	Starts the system with a ”start“ command applied to a digital input.	In slave mode start and stop command comes via bus. The drive can be switched off separately the signal “Run Enable (P3.9) assigned to a terminal. If this command is removed, the drive stops. In master mode the drive starts with a start command at a digital input.	The slave receives the start and stop command via bus. It can be switched off separately with the signal “Run Enable (P3.9) assigned to a terminal. If this command is removed, the drive stops.
Reference value			
	Signal 0 … 10 V via potentiometer, which is supplied by the internal voltage of DG1. Analog input AI1 is used. The analog input and the PID controller must be configured accordingly. The signal commons of the supply voltage (GND, terminal 6) and the analog input (AI1-, terminal 3) must be linked.		Not necessary
Source for speed reference	PID1 Controller Output (17)	PID1 Controller Output (17)	Not necessary
Regulation source	P18.5.2 = PID Controller 1 (1)	P18.5.2 = PID Controller 1 (1) In master mode the drive receives its speed reference from the output of the internal PID controller, in slave mode it comes via bus.	Network only (0)
Feedback			
	Signal 0 … 10 V from an external sensor. Analog input AI2 is used. The analog input and the PID controller must be configured accordingly. The signal commons of the external sensor and the analog input (AI2-, terminal 5) must be linked.		Not necessary
Pipe filling			
Enabling	P18.6.7 = DigIN: Normally Close (1)	P18.6.7 = DigIN: Normally Close (1)	Not necessary
Settings level 1	P18.6.8 up to P18.6.11 Application dependent	P18.6.8 up to P18.6.11 Application dependent	
Settings level 2	P18.6.12 up to P18.6.15 Application dependent	P18.6.12 up to P18.6.15 Application dependent	
Reporting	P5.4 = Prime Pump Active (57)	P5.4 = Prime Pump Active (57)	
Adding pumps to and removing them from the system			
Frequency when adding	P18.1.4	P18.1.4	Not necessary
Frequency when removing	P18.1.5	P18.1.5	
Band width	P18.1.3	P18.1.3	
Delay time	P18.1.6	P18.1.6	

4.2.4.3 Example 3: 3 masters, sequence according run time

A pump system consists out of 3 speed controlled drives, where max. two arbitrary drives run simultaneously. All three drives must be able to operate as master. The two drives with the lowest run time shall operate. An exchange of a drive must be possible. In this situation the system shall continue to run. Before the system starts, the pipes inside the system shall be filled with water to prevent a water hammer at start (2 filling levels). The filling procedure shall be reported with relay RO1. The reference comes from a potentiometer as signal 0 … 10 V. The feedback value comes from a sensor 0 … 10 V. The variable frequency drive #3 is physically the last one at the bus.



Reference and feedback value must be applied to the master as well as to the standby master. Because the system has to run, even when exchanging the original master, the supply for the reference must be maintained. Therefore the 10 V supplies of all drives are wired in parallel. Backup diodes must be used.

Practice tip: Because the drives are configured identically except the drive ID, it is recommended to configure the drive #1 completely first and to copy the parameter set afterwards to drive #2 and #3. At the end, the drive ID of the drives #2 and #3 (P18.1.2) must be changed to a value different from drive #1.

	DG1 #1 Master / Slave	DG1 #2 Master / Slave	DG1 #3 Master / Slave
Selection of the mode of operation			
Multi-pump Mode	P18.1.1 = Multi Drive Network (2)	P18.1.1 = Multi Drive Network (2)	P18.1.1 = Multi Drive Network (2)
Maximum No. of pumps, which run simultaneously	P18.5.1 = 2	P18.5.1 = 2	P18.5.1 = 2
Bus			
Control	The master drive controls the slaves via the bus. The terminals 25 (A) and 26 (B) of all drives involved, must be connected in parallel.		
DIP switch „RS485 Termination“	Res_disconn	Res_disconn	Res_conn
Drive ID	P18.1.2 = 1	P18.1.2 = 2	P18.1.2 = 3
RS485 Baud rate (must be equal at all drives)	P20.3.2.2 = 38400 (2)	P20.3.2.2 = 38400 (2)	P20.3.2.2 = 38400 (2)
Start			
	The respective master starts the system with a „start” command at a digital input. The slaves receive a start and stop command via bus. The drive can be switched off separately with the signal “Run Enable (P3.9) assigned to a terminal. If this command is removed, the drive stops.		
Reference value			
	Signal 0 … 10 V via potentiometer, which is supplied by the internal voltage of DG1. Analog input AI1 is used. The analog input and the PID controller must be configured accordingly. The signal commons of the supply voltage (GND, terminal 6) and the analog input (AI1-, terminal 3) must be linked.		
Source for speed reference	PID1 Controller Output (17)	PID1 Controller Output (17)	PID1 Controller Output (17)
Regulation source	P18.5.2 = PID Controller 1 (1) In master mode the drive receives its speed reference from the output of the internal PID controller, in slave mode it comes via bus.	P18.5.2 = PID Controller 1 (1) In master mode the drive receives its speed reference from the output of the internal PID controller, in slave mode it comes via bus.	P18.5.2 = PID Controller 1 (1) In master mode the drive receives its speed reference from the output of the internal PID controller, in slave mode it comes via bus.
Feedback			
	Signal 0 … 10 V from an external sensor. Analog input AI2 is used. The analog input and the PID controller must be configured accordingly. The signal commons of the external sensor and the analog input (AI2-, terminal 5) must be linked.		
Pipe filling			
Enabling	P18.6.7 = DigIN: Normally Close (1)	P18.6.7 = DigIN: Normally Close (1)	P18.6.7 = DigIN: Normally Close (1)
Settings level 1	P18.6.8 up to P18.6.11 Application dependent	P18.6.8 up to P18.6.11 Application dependent	P18.6.8 up to P18.6.11 Application dependent
Settings level 2	P18.6.12 up to P18.6.15 Application dependent	P18.6.12 up to P18.6.15 Application dependent	P18.6.12 up to P18.6.15 Application dependent
Reporting	P5.4 = Prime Pump Active (57)	P5.4 = Prime Pump Active (57)	P5.4 = Prime Pump Active (57)
Adding pumps to and removing them from the system			
Frequency when adding	P18.1.4	P18.1.4	P18.1.4
Frequency when removing	P18.1.5	P18.1.5	P18.1.5
Band width	P18.1.3	P18.1.3	P18.1.3
Delay time	P18.1.6	P18.1.6	P18.1.6
Switching depending on the run time			
	P18.5.5 = Run Time (1) P18.5.6 = Enabled (1)	P18.5.5 = Run Time (1) P18.5.6 = Enabled (1)	P18.5.5 = Run Time (1) P18.5.6 = Enabled (1)

4.2.5 Status information

With the setting P18.1.1 „Multi-pump Mode“ = „Multi Drive Network (2)“ the status of all drives in the system are displayed on each drive.

Parameter	Name	Range	
P18.2.1.1	Operation Mode Drive 1	Offline (0) Slave Drive (1) Master Drive (2)	· Offline (0): The drive is not in multi drive mode (P18.1.1 = Multi Drive Network (2)) or it is a slave in the multi drive network, which has lost the communication with the master. · Slave (1): Slave inside a multi drive network · Master (2): Master in a multi drive network
P18.2.1.2	Operation Mode Drive 2	like P18.2.1.1	
P18.2.1.3	Operation Mode Drive 3	like P18.2.1.1	
P18.2.1.4	Operation Mode Drive 4	like P18.2.1.1	
P18.2.1.5	Operation Mode Drive 5	like P18.2.1.1	
P18.2.2.1	Multi Pump Status Drive 1	Stopped (0) Sleep (1) Regulating (2) Wait for CMD (3) Following (4) Unknown (5)	· Stopped (0): For master or single drive that is stopped · Sleep (1): For master or single drive that is asleep · Regulating (2): For master or single drive which is running · Wait for CMD (3): For slave drive which is stopped · Following (4) For slave drive which is running · Unknown (5) Status for disconnected drives showing on the other drives menu.
P18.2.2.2	Multi Pump Status Drive 2	like P18.2.2.1	
P18.2.2.3	Multi Pump Status Drive 3	like P18.2.2.1	
P18.2.2.4	Multi Pump Status Drive 4	like P18.2.2.1	
P18.2.2.5	Multi Pump Status Drive 5	like P18.2.2.1	

Parameter	Name	Range	
P18.2.3.1	Network Status Drive 1	Disconnected (0) Fault (1) Pump lost (2) Need Alternation (3) No error (4)	· Disconnected (0): Disconnected slave drive, single drive or MPFC is disabled. · Fault (1) For drives that suffer fault · Pump lost (2): For drive that lose interlock signal · Need Alternation (3): For drives with a run time above limit . No error (4)
P18.2.3.2	Network Status Drive 2	like P18.2.3.1	
P18.2.3.3	Network Status Drive 3	like P18.2.3.1	
P18.2.3.4	Network Status Drive 4	like P18.2.3.1	
P18.2.3.5	Network Status Drive 5	like P18.2.3.1	

4.2.6 Operating data

With the setting P18.1.1 „Multi-pump Mode“ = „Multi Drive Network (2)“ the operating data of all drives in the system are displayed at the drive, which is acting as master.

Parameter	Name	Range
P18.3.1.1	Latest fault code drive 1[1)]	0 No fault 1 Over Current 2 Over Voltage 3 Earth Fault 5 Charging Switch 6 Emergency Stop 7 Saturation Trip 9 Under Voltage 10 Input Phase Spv 11 Output Phase Spv 12 Brake Chopper Spv 13 Drive Under Temp 14 Drive Over Temp 15 Motor Stalled 16 Motor Over Temp 17 Motor Under Load 18 IP Address Conflict 19 Power Board EEPROM Fault 20 FRAM Fault 21 Serial Flash Fault 25 MCU Watchdog Fault 26 Start-up Prevent 29 Thermistor Fault 32 Fan cooling 36 Compatibility Fault 37 Device Change 38 Device Added

Parameter	Name	Range
		39 Device Removed 40 Device Unknown 41 IGBT Temperature 50 AIN<4mA (4to20mA) 51 External Fault 52 Keypad Communication Fault 54 OPT Card Fault 55 Real time clock fault 56 PT100 Fault 57 Motor ID Fault 58 Current Measure Fault 59 Possible power wiring error detected 60 Control Board Over Temp 61 Internal-ctrl Supply 62 Too Many Speed Search Restarts 63 Current Unbalance 64 Replace Battery 65 Replace Fan 66 Safety Torque Off 67 Current Limit Control 68 Over voltage control 69 System Fault 70 System Fault 71 System Fault 72 Power Board EEPROM Fault 73 FRAM Fault 74 FRAM Fault 75 Power Board EEPROM Fault 76 Power Board EEPROM Fault 77 Serial Flash Fault 82 BypassOverLoad 83 FieldBus Fault 84 FieldBus Fault 85 FieldBus Fault 86 FieldBus Fault 87 FieldBus Fault 88 FieldBus Fault 89 Under Voltage 90 Drive Under temp 91 Option Card Fault 92 External Fault 2 93 External Fault 3
P18.3.1.2	Latest fault code drive 2[1)]	like P18.3.1.1
P18.3.1.3	Latest fault code drive 3[1)]	like P18.3.1.1
P18.3.1.4	Latest fault code drive 4[1)]	like P18.3.1.1
P18.3.1.5	Latest fault code drive 5[1)]	like P18.3.1.1
P18.3.2.1	Output Frequency Drive 1	Output Frequency in Hz
P18.3.2.2	Output Frequency Drive 2	Output Frequency in Hz
P18.3.2.3	Output Frequency Drive 3	Output Frequency in Hz
P18.3.2.4	Output Frequency Drive 4	Output Frequency in Hz
P18.3.2.5	Output Frequency Drive 5	Output Frequency in Hz

Parameter	Name	Range
P18.3.3.1	Motor Voltage Drive 1	Motor Voltage in V
P18.3.3.2	Motor Voltage Drive 2	Motor Voltage in V
P18.3.3.3	Motor Voltage Drive 3	Motor Voltage in V
P18.3.3.4	Motor Voltage Drive 4	Motor Voltage in V
P18.3.3.5	Motor Voltage Drive 5	Motor Voltage in V
P18.3.4.1	Motor Current Drive 1	Motor Current in A
P18.3.4.2	Motor Current Drive 2	Motor Current in A
P18.3.4.3	Motor Current Drive 3	Motor Current in A
P18.3.4.4	Motor Current Drive 4	Motor Current in A
P18.3.4.5	Motor Current Drive 5	Motor Current in A
P18.3.5.1	Motor Torque Drive 1	Motor Torque in %
P18.3.5.2	Motor Torque Drive 2	Motor Torque in %
P18.3.5.3	Motor Torque Drive 3	Motor Torque in %
P18.3.5.4	Motor Torque Drive 4	Motor Torque in %
P18.3.5.5	Motor Torque Drive 5	Motor Torque in %
P18.3.6.1	Motor Power Drive 1	Motor Power in %
P18.3.6.2	Motor Power Drive 2	Motor Power in %
P18.3.6.3	Motor Power Drive 3	Motor Power in %
P18.3.6.4	Motor Power Drive 4	Motor Power in %
P18.3.6.5	Motor Power Drive 5	Motor Power in %
P18.3.7.1	Motor Speed Drive 1	Motor Speed in rpm
P18.3.7.2	Motor Speed Drive 2	Motor Speed in rpm
P18.3.7.3	Motor Speed Drive 3	Motor Speed in rpm
P18.3.7.4	Motor Speed Drive 4	Motor Speed in rpm
P18.3.7.5	Motor Speed Drive 5	Motor Speed in rpm
P18.3.8.1	Run Time Drive 1	Run Time in h
P18.3.8.2	Run Time Drive 2	Run Time in h
P18.3.8.3	Run Time Drive 3	Run Time in h
P18.3.8.4	Run Time Drive 4	Run Time in h
P18.3.8.5	Run Time Drive 5	Run Time in h

1) A list of the possible root causes for the faults can be found inside the application manual MN040004EN.