

MEKATORA CONTROL SYSTEMS

MKT-VFP-1800d

Helix series, distribution variant

Distribution Pump Station

Device tag **P-701**

Duty/standby distribution pump set with PID pressure control.

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Precision Through Automation

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1 Overview

The **MKT-VFP-1800d** (Helix series, distribution variant) is a duty/standby distribution pump station: two MKT-VFP-1800d skids in parallel, one on duty and one on standby. Each pump is a single-stage centrifugal unit driven by an integrated vector-controlled variable-frequency drive. The PID loop modulates VFD speed to hold a constant network discharge pressure as municipal demand fluctuates.

The duty pump is selected by PUMP1_SEL or PUMP2_SEL; the standby unit can be brought online manually or automatically on duty fault. The drive provides motor-current and -temperature diagnostics and a cavitation-damage counter that pits the impeller permanently if the pump runs against an empty supply tank.

2 Process specifications

Parameter	Value
Pumps in parallel	2 (duty + standby)
Rated flow per pump	180 m ³ /h at 100 % speed
Rated discharge pressure	nominal 5 bar (PID-driven)
Pressure setpoint range	0.0–8.0 bar
Speed control	VFD, 0–100 % (auto via PID)
VFD ramp time-constant	2 s (first-order, soft-start)
Rated motor current	~41 A at rated flow
Motor thermal model	25 °C ambient, +45 °C rise at rated
Thermal lag	60 s first-order
Cavitation damage rate	1 %/s while running with supply < 5 %
Damage no-impact threshold	< 30 % (FAULT_CODE remains 0)
Damage hard-fault threshold	>= 30 % (FAULT_CODE = 3)
Damage clearing	physical impeller replacement only

Discharge pressure tracks the setpoint via the PID loop:

$$P_{disch} \rightarrow \text{PRESSURE_SP} \cdot \frac{\text{SPEED_PV}}{100} \cdot \text{health}$$

clamped to $\text{PRESSURE_SP} \times 1.2$. Motor current scales linearly with flow:

$$I_{motor} \approx 5.0 + 0.20 \cdot Q \quad [\text{A}]$$

where Q is the delivered flow in m³/h.

A **health** factor multiplies both flow capacity and developed head linearly toward zero from 30 % to 100 % accumulated damage. At 100 % damage the pump produces no flow regardless of speed.

3 Network configuration

Item	Value
IP address	172.28.0.201
Subnet	172.28.0.0/24
TCP port	502 (Modbus TCP)
Unit identifier	echoed in the response; not validated
Byte order	big-endian (Modbus standard)

4 Register map

Modbus uses 1-based “register numbers” in narrative; the on-the-wire PDU address is **register_number** - 1. Both columns are shown. All scaled fields are signed 16-bit integers; engineering value = wire / scale.

4.1 Coils (FC 01 read · FC 05 / 0F write)

Reg	Addr	Name	R/W	Description
1	0x000	RUN_CMD	RW	Enables the duty pump.
2	0x001	PUMP1_SEL	RW	Selects pump #1 as duty.
3	0x002	PUMP2_SEL	RW	Selects pump #2 as duty.

4.2 Holding registers (FC 03 read · FC 06 / 10 write · FC 16 mask · FC 17 read+write)

Reg	Addr	Name	Scale	Range	Unit	R/W	Description
1	0x000	SPEED_SP	x10	0..1000	0..100 %	RW	Manual speed override; 0 = auto (PID-controlled).
2	0x001	PRESSURE_SP	x100	0..800	0..8 bar	RW	PID setpoint for discharge pressure.

Writes to both setpoints are clamped to the engineering range.

SPEED_SP = 0 switches the drive to auto mode where a real PI loop adjusts target speed against the measured **DISCHARGE_P** to track **PRESSURE_SP**. Anti-windup clamps the integrator at +/-200; the controller transfers bumplessly when the operator switches between manual and auto. Any non-zero **SPEED_SP** forces fixed-speed manual mode and bypasses the loop.

4.3 Input registers (FC 04 read only)

Reg	Addr	Name	Scale	Type	Unit	Description
1	0x000	SPEED_PV	x10	int16	%	Actual VFD output speed.

Reg	Addr	Name	Scale	Type	Unit	Description
2	0x001	DISCHARGE_P	x100	int16	bar	Discharge pressure to network.
3	0x002	FLOW	x10	int16	m ³ /h	Delivered flow.
4	0x003	MOTOR_I	x10	int16	A	Motor current.
5	0x004	MOTOR_T	x10	int16	°C	Motor winding temperature.
6	0x005	FAULT_CODE	x1	uint16	code	0 = ok, 3 = impeller damaged, 4 = no pump selected.
7	0x006	IMPELLER_DAMAGE	x10	int16	%	Cumulative cavitation damage 0..100.
8	0x007	PUMP1_RUN_HOURS_HI	x1	uint16	h	High word of Pump 1 run-hours counter.
9	0x008	PUMP1_RUN_HOURS_LO	x1	uint16	h	Low word of Pump 1 run-hours counter.
10	0x009	PUMP2_RUN_HOURS_HI	x1	uint16	h	High word of Pump 2 run-hours counter.
11	0x00A	PUMP2_RUN_HOURS_LO	x1	uint16	h	Low word of Pump 2 run-hours counter.

FAULT_CODE semantics:

- **3** — impeller damaged from cavitation; latches once asserted, only a deliberate operator plant reset clears it (after physical repair).
- **4** — no pump selected; clears as soon as PUMP1_SEL or PUMP2_SEL is asserted. While latched, FLOW is zero regardless of speed setpoint.

Per-pump run-hours accrue only on the selected pump while the pump set is moving water (SPEED_PV > 1 %). Operators alternate PUMP1_SEL and PUMP2_SEL weekly to equalise wear.

5 Supported function codes

FC	Name	Notes
0x01	Read Coils	
0x02	Read Discrete Inputs	(none defined; returns illegal address)
0x03	Read Holding Registers	
0x04	Read Input Registers	
0x05	Write Single Coil	
0x06	Write Single Register	
0x0F	Write Multiple Coils	
0x10	Write Multiple Registers	
0x16	Mask Write Register	
0x17	Read/Write Multiple Registers	
0x2B/0x0E	Read Device Identification	conformity 0x82

Serial-line / file-record / FIFO function codes return exception **0x01 (illegal function)**.

5.1 Exception codes

Code	Meaning	When the device returns it
0x01	Illegal function	FC not in the table above.
0x02	Illegal data address	Register/coil out of range, or start + count > 0x10000.
0x03	Illegal data value	Quantity out of range, or coil value not 0x0000 / 0xFF00.
0x04	Server device failure	Internal binding error.

6 Device identification (FC 0x2B / MEI 0x0E)

Conformity level **0x82** (regular).

Object ID	Name	Value
0x00	VendorName	Mekatora Control Systems
0x01	ProductCode	MKT-VFP-1800d
0x02	MajorMinorRevision	firmware version (set at build time)
0x03	VendorUrl	https://mekatora.com
0x04	ProductName	Distribution Pump Station
0x05	ModelName	Helix series (distribution variant)
0x06	UserApplicationName	P-701 (device tag)

7 Operating notes

In normal operation leave `SPEED_SP = 0` and let the PID hold the network at `PRESSURE_SP`. Typical municipal-distribution setpoints:

Network character	PRESSURE_SP
Short, flat urban	3.5–4.5 bar
Medium, mixed elevation	4.5–5.5 bar
Tall buildings, long mains	5.5–6.5 bar

On startup, confirm `T-601 LEVEL > 30 %` before asserting `RUN_CMD` — this is the only reliable way to avoid cavitation damage. Once running, watch `DISCHARGE_P` track `PRESSURE_SP` within ~5 s; large oscillations indicate the PID needs tuning.

Alternate `PUMP1_SEL` / `PUMP2_SEL` weekly to equalise wear on the two pumps. The standby unit is held inert until the duty pump trips or the operator switches manually.

Interlocks and hazards. Running below `T-601`'s low-level setpoint cavitates the impeller and pits it within hours — `IMPELLER_DAMAGE` accumulates at 1 %/s while the supply factor is below 5 %. Past 30 % damage `FAULT_CODE` latches to 3 and capacity falls linearly to zero at 100 % damage; the only fix is a physical replacement.

Stopping `RUN_CMD` with the network full and demand active causes a water-hammer event when consumers continue drawing. Close the network isolation valve before stopping. Manual `SPEED_SP = 100 %` bypasses pressure control — old mains may not survive the resulting transient. Both `PUMP1_SEL` and `PUMP2_SEL` simultaneously may surge if the system curves don't match; verify the P&ID supports parallel operation before forcing it.

Over-pressure. `SPEED_SP` above zero takes the drive out of pressure control and the network sees whatever the pump curve produces at that flow. Above 7 bar the console raises a main-stress warning, since old cast-iron mains leak progressively at that pressure; above 9 bar it raises a burst-risk alarm. Neither is interlocked: the drive will hold the speed you asked for.

8 Appendix A — Example transactions

8.1 A.1 — Set network pressure to 4.5 bar (FC 06, register 2 = address 0x0001)

Wire value = 4.5 x 100 = 450 = 0x01C2.

```
0001 0000 0006 01 06 0001 01C2
```

8.2 A.2 — Read full status block (FC 04)

Read 7 registers from address 0x0000:

```
0002 0000 0006 01 04 0000 0007
```

Reply (14 bytes payload):

```
0002 0000 0011 01 04 0E 028A 01C2 04B0 0136 02BC 0000 0000
    \ / \_ / \_ / \_ / \_ / \_ / \_ /
    FC bc SPDPV DPRSS FLOW MOTI MOTT FAULT DMG
        65.0% 4.50 120.0 31.0 70.0 ok 0%
```

8.3 A.3 — Switch to standby pump (FC 0x0F atomic)

Write 2 coils starting at address 0x0001 with bits 01 (Pump 1 OFF, Pump 2 ON):

```
0003 0000 0008 01 0F 0001 0002 01 02
      \ / \_ / \_ / \ / \ /
      FC start qty  bc bits
```

The bit pattern is LSB-first: byte 0x02 = 0b00000010 selects coil 2 (PUMP2_SEL) and clears coil 1 (PUMP1_SEL).

8.4 A.4 — Read identification (FC 0x2B / MEI 0x0E)

```
0004 0000 0005 01 2B 0E 01 00
```

9 Appendix B — Address convention quick reference

The Modbus PDU carries **register_number - 1**. Tools asking for “Modbus register address” usually want the **0-based PDU value**; tools asking for “register number” want the **1-based** value.