2-PHASE STEPPING MOTOR DRIVER

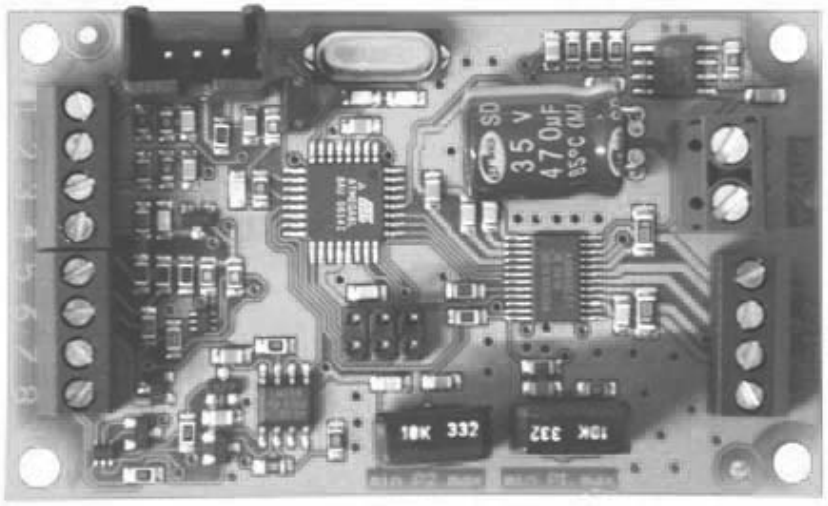
FE Z4 TRANSFER

For Diaphragm Dosing Pumps
FEM 1.02 / FEM 1.09

Controller board package, without pump: ID 157870

Operating and Installation Manual

It is important to read and comply with all instructions in this operating and installation manual.



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Contents **page**

1. About this document

1.1. Use of the operating and installation manual

The operating and installation manual forms an integral part of the controller.

➔ Please be sure to pass the manual on to the next owner of the device.

Project controller

Specifications and instructions for customer-specific project controllers (model numbers beginning with “PL” or “PML”) may differ from those set down in the operating and installation manual.

➔ For project controllers, it is also necessary to observe the agreed specifications.

1.2. Symbols and flags

Warning symbol

WARNING

Warning regarding a potential danger.

Possible consequences of failure to comply with the warning. The word used, e.g. “warning”, indicates the level of danger present.

➔ Precautions required to prevent the danger and its consequences.

Levels of danger

Word	Meaning	Consequences of non-compliance
DANGER	Warning of an imminent danger	Death or serious injury, or major damage to property
WARNING	Warning of a potential danger	Possible death or serious injury, or major damage to property
CAUTION	Warning of a potentially dangerous situation	Possibility of slight injury or damage to property

Tab. 1: Levels of danger

Other flags and symbols

➔ Identifies an action (step) to be carried out.

1. Identifies the first step of an action. Further numbered steps follow.

i Identifies important information.

1.3. Terminology, Definitions

In this document the expression pump is used for a Diaphragm Dosing Pump FEM1.02 or FEM1.09 and controller or pump controller is used for a 2-Phase Stepping Motor Driver for a Diaphragm Dosing Pump FEM 1.02 or FEM 1.09

RPM = revolutions per minute.

2. Use

2.1. Intended use

The controller is exclusively intended to drive the 2-phase stepper motor of the FEM 1.02, FEM 1.09 pumps.

Owner's responsibility

Operating parameters and conditions

Only install and operate the controller and the pumps under the operating parameters and conditions described in Chapter 4, Technical Data.

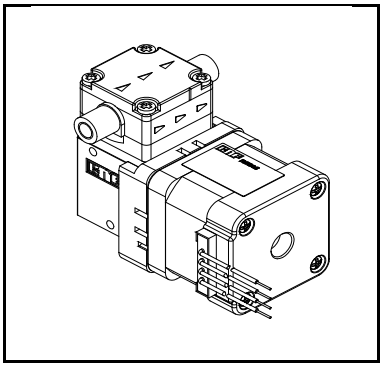

Fig. 1: FEM 1.02

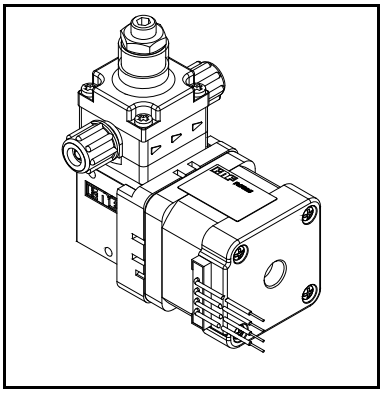

Fig. 2: FEM 1.09 .27

2.2. Improper use

The controller and the pumps must not be operated in a potentially explosive atmosphere.

The ambient temperature for the controller board is limited to 40° Celsius maximum.

Handle this pump controller only conform to ESD protection standards (Electrostatic Discharge).

Do not use this pump controller board at high humidity or condensing conditions.

Prevent the controller from being contaminated or contacted with any liquids, solvents or vapors.

Prevent the controller from being uncontrolled connected to conductive wires or materials.

3. Safety

Read the safety instruction in sections 5. Installation and connection, and 6. Operation.

For security reasons consult first the KNF Flodos “Operating Instruction ID 157639 - Diaphragm Dosing Pump FEM1.02 or FEM1.09” before starting a pump application. Take notice of all the related description, especially concerning the safety, the technical data and the pump performance.

The controller is constructed according to the generally accepted rules of the technology, and occupational health and safety and accident prevention provisions. Hazardous situations with the possibility of injuries to the user or other persons, or damage to the controller or other property, may, however, occur during use of the device.

The controller must be operated only in technically sound condition and for its intended purpose, with due regard for safety and potential hazards and in accordance with this operating and installation manual.

Personnel

Make sure that all persons working with the controller have been appropriately trained and familiarized with its use, or are qualified personnel. This applies particularly to the assembly, connection and maintenance of the equipment.

Make sure that the relevant personnel have read and understood this operating and installation manual, particularly the chapter on safety.

Safety awareness

Accident prevention and safety rules must be observed at all times while working on or using the controller or the pump.

Hazardous media

When pumping a hazardous medium, always observe the safety rules for the medium in question.

Signs

Always comply with instruction signs placed on the pump, such as flow direction arrows and the type plate, and keep these in a clearly legible condition.

Environmental protection

All replacement parts must be stored and disposed of in accordance with the precautions required under environmental protection provisions. It is important to comply with both national and international regulations. This applies particularly to parts that have been contaminated with toxic materials.

Disposal

Dispose of all packaging in an environmentally appropriate manner. The packaging materials are recyclable.

Ensure that the controller is disposed of in an environmentally appropriate manner at the end of its useful life. Use appropriate waste collection systems for the disposal of end-of-life equipment. Used controllers contain valuable recyclable materials.

EU directives/standards

The pumps are in accordance with the requirements of the guidelines 2011/65/EU (ROHS2)

The diaphragm liquid pumps conform with the EU safety requirements and guidelines for the electromagnetic compatibility 2004/108/EC.

According to the machinery directive 2006/42/EG pumps are incomplete machines and are thus to be considered as not ready for use. The partly completed machinery must not be put into service until the final machinery into which it is to be incorporated has been declared in conformity with the provisions of the Directive 2006/42/EC. The Basic requirements of the machinery directive 2006/42/EC according to appendix I (general principles) are applied and fulfilled.

The pump controller board connected to a Diaphragm Dosing Pump FEM1.02 or FEM1.09 with maximum 1 meter of power supply cables are in accordance to the following standards:

- EN 61000-6-2
- EN 61000-6-3

Customer service and repairs

All repairs to the pumps must be carried out solely by the accredited KNF customer service team.

Use only KNF original parts for all maintenance work.

4. Technical data

4.1. Electrical data

Parameter	Value
Supply voltage [V DC]	10 V … 28 V (24 V ± 10% for full pump performance)
Max. current consumption, DC RMS 24 V [A]	0.8 A
Stepper driver Current [A/Phase] RMS	0 … 0.5 (optional 0 … 1.2)
Stepper driver Stepping mode	2-Phase 8 Micro steps
Protection class	IP 00
Connection	Connector with leads

Tab. 2: Electrical data

4.2. External drive

Parameter	Value
Signal Ground COM 1	
	GND is internally connected to PWR-GND, all input and output signals are referenced to this GND level.
Analogue input COM 2,3	
Signal range	0–10 V, 4–20 mA
Input resistance [Ω]	20 kΩ at 0–10 V 220 Ω at 4–20 mA
Digital input COM 4,5,6	
Signal range	Pull up at 24 V
Electric strength [V] TTL	24 V DC
Low level (ON)	< 0.8 V = low
High level (OFF)	> 2.0 V = high
Digital output COM 7	
Electric strength, open collector [V] TTL	35 V DC
Load capability, open collector [mA]	20 mA
Reference output COM 8	
Output voltage [V DC]	10 V
Load capability [mA]	10 mA

Tab. 3: External drive

4.3. Other parameters

Parameter	Value
Permitted ambient temperature	+5 to +40°C
Humidity	Not condensing
Weight of the controller[1)] [g]	24

Tab. 4: Other parameters
1) Weight without connecting wires.

5. Structure and operation

5.1. Introduction

The 2-Phase Stepping Motor Driver is a stepper motor controller to operate the KNF Flodos Diaphragm dosing pump FEM 1.02 / FEM 1.09.

The operating instructions are to be used together with the operating instructions
ID 157639 “Diaphragm dosing pump FEM1.02 or FEM1.09”

5.2. Features

- ➔ Easy and precise pump control with high flexibility in process integration
- ➔ Wide supply voltage range 10 … 28VDC
- ➔ Constant current 2-phase stepper motor driver, adjustable 0 … 0.5 A rms per phase
  (Optional 0 … 1.2 A rms)
- ➔ Micro stepping: 8 micro steps = 1 full step, 1600 micro steps = 1 full revolution
- ➔ Flow rate (motor speed) control 0.1 … 200 RPM by:
  - internal Trimmer
  - external Voltage 0 … 10 V
  - external Current 4 … 20 mA
  - external Impulse, 1 impulse / micro step
  - external Potentiometer
- ➔ Digital I/Os for pump motor control: START/STOP, DIR rotation direction normal / reverse
- ➔ Integrated supply & connector for HALL type position sensor for speed monitoring or additional pump functions
- ➔ REF – output 10 VDC, 10 mA, to supply an external sensor or potentiometer
- ➔ On-board circuits for thermal protection and short circuit protection of motor phase current
- ➔ Compact size 72mm x 43mm x 25mm, fits into DIN-Rail housings for 72mm PCB

6. Assembly and connection

Only install and operate the controller under the operating parameters and conditions described in chapter 4, Technical data. Observe the safety instructions in chapter 3.

6.1. Assembly

Handle this pump controller only in accordance to the ESD standards (Electrostatic Discharge).

Mounting dimensions

➔ Mounting dimensions (see fig. 3)

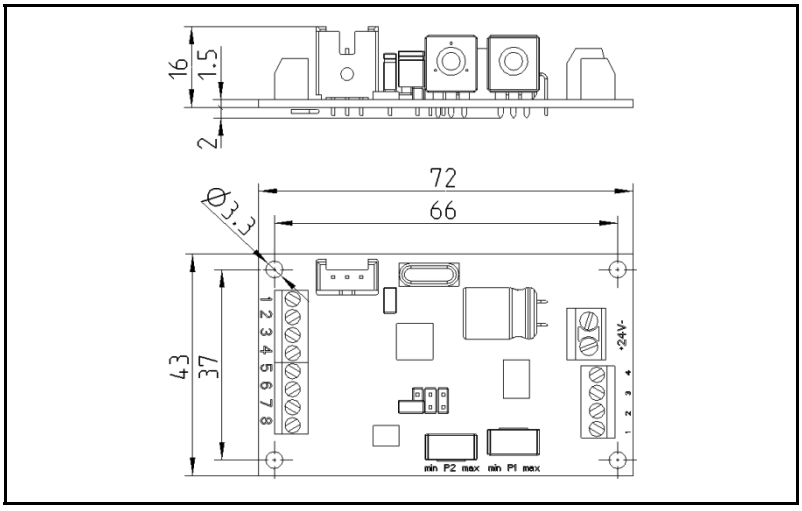

Fig. 3: Dimension FE Z4

Installation

➔ Make sure that the installation location is dry and the controller is protected against rain, splash, hose and drip water.

➔ Protect the controller from dust.

➔ Protect the controller from vibrations and jolts.

6.2. Electrical Connection

1. Connect the 4 wires of the pump motor to the **MOT** terminals of the controller (see tab. 5).
2. Connect the wires for remote control to the **COM** connector (see tab. 5 and section 6). As needed for the application.
3. Adjust trimmers and jumpers according to the application. (see tab. 6, 7 and section 6)
4. Apply 24 VDC supply voltage to the **PWR** power supply terminals.

Make sure your power supply can deliver at least 0.8A.

6.3. Connectors

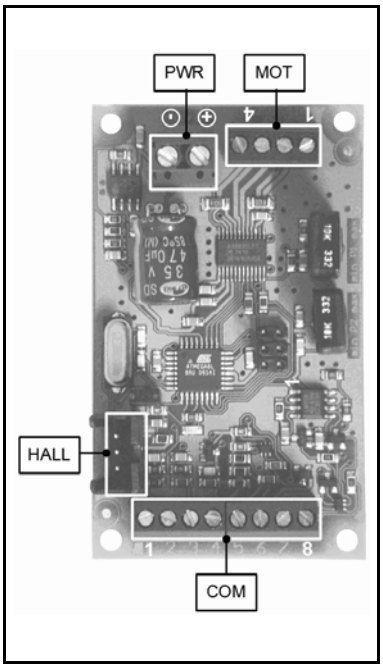

Fig 4: Location of connectors

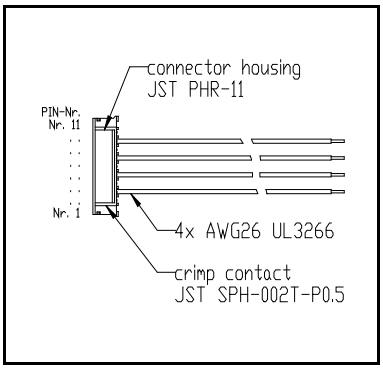

Fig. 5: Motor wire

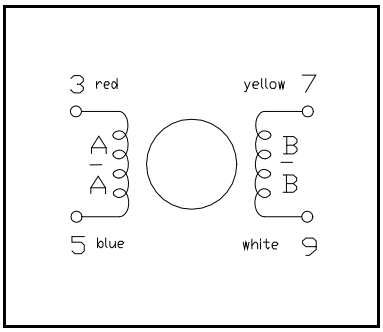

Fig. 6: Motor windings bipolar

	Pin No.	Signal Name	Function
PWR	+	+24V	+ Power supply 10 … 28 VDC.
	-	PWR-GND	- Power supply. Power Ground
MOT	1	B-	Motor phase B- (white wire)
	2	B+	Motor phase B+ (yellow wire)
	3	A-	Motor phase A- (blue wire)
	4	A+	Motor phase A+ (red wire)
COM	1	GND	Signal Ground internally connected to PWR-GND Reference level for COM signals
	2	0 … 10 V Analogue Input	RPM control 0V = 0 RPM 10V = 200 RPM max.
	3	4 … 20 mA Analogue Input	RPM control 4mA = 0 RPM 20mA = 200 RPM max.
	4	Impulse Digital Input	1 impulse = 1 motor micro step 8 impulses = 1 motor full step 1600 impulses = 1 motor full revolution
	5	Disable Digital Input	Disables motor drive current.
	6	DIR Digital Input	Reverses direction of motor rotation
	7	Hall – Output	Hall sensor output signal, while using the optional hall sensor. Open collector
	8	REF – Output	Reference voltage output drives 10 VDC, 10mA max load current
	Note: All Digital Input levels are TTL levels, but they can be driven up to 24 VDC		
HALL	The diaphragm dosing pump FEM 1.02 and FEM 1.09 can optional be equipped with a hall sensor to realize a position sensor. Plug the sensor into the HALL Socket.		

Tab. 5 Connectors

6.4. Trimmers

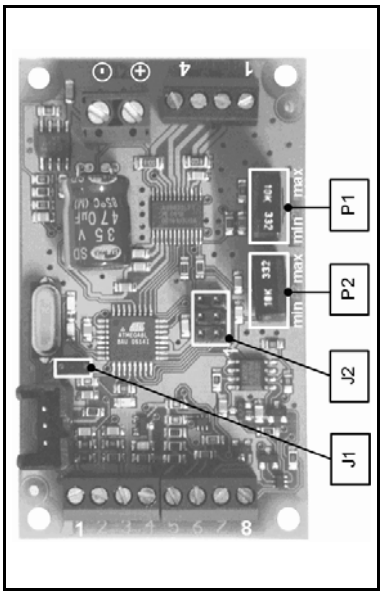

Fig 7: Location of trimmers and jumpers

	Function
P1	Motor current setting The default setting is 0.33 A rms per phase. This is about the middle position of trimmer P1. ℹ High motor current settings increase the pump performance for higher pressure. Higher settings increase the motor temperature. ℹ Low motor current settings reduce the motor temperature. High pumping pressures may not be achieved. ⚠ **CAUTION** High motor current causes high motor temperature. Hot surface danger of burns Motor iron temperature above 100°C causes motor damage.
P2	Pump flow rate limit setting. max = 200 rpm min = 140 rpm Setting of P2 limits the pump flow rate range controllable by an external control signal 0V - 10V respectively 4 - 20mA. Use Jumper J2 for other rpm range settings

Tab. 6 Trimmers

6.5. Jumpers

	Setting	Function
J1	Closed 	No external RPM control. The motor runs with the RPM set by P2 and J2 (factory setting)
	Open 	External RPM control by 0 -10V or 4-20mA analogue input signal. The maximum RPM is set by the setting of P2 and J2.
J2	Open 	140 – 200 RPM range of P2 (factory setting)
	Pin 3 – 4 	75 – 150 RPM range of P2
	Pin 1 – 3 	0 – 82 RPM range of P2

Tab. 7 Jumper settings

ℹ Before changing position of the jumper, turn the power supply at the PWR connector off. Otherwise the jumper settings will not apply.

7. Operation

➔ The controllersshould only be used under normal operating parameters / conditions which are described in section 4 – technical data.

➔ Ensure that the controller is used correctly (see section 2.1).

➔ Improper use of the controllers must be avoided (see section 2.2).

➔ Observe the safety notes (see chapter 3).

➔ The controller is a components which has to be integrated into a machine. Before it is put into operation it is important to ensure that the machine / equipment complies with the appropriate regulations.

CAUTION

Danger of burning
The motor heats up

➔ Don't touch the motor

➔ Don't let the motor come in contact with flammable materials

7.1. Operation without external control of flow rate

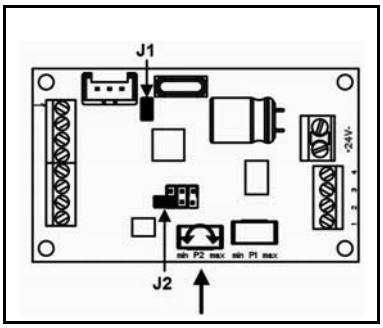

Fig. 8: No external flow rate control J1 closed

➔ Close Jumper J1

➔ Connect Power supply to the PWR DC Power Clamps

➔ Adjust trimmer P2 and Jumper J2 until the pump operates at the flow rate needed.

i Before changing position of the jumper, turn the power supply at the PWR connector off. Otherwise the jumper settings will not apply.

➔ The pump will start at power up and it stops at power down

7.2. Setting to a constant flow rate by using an external potentiometer

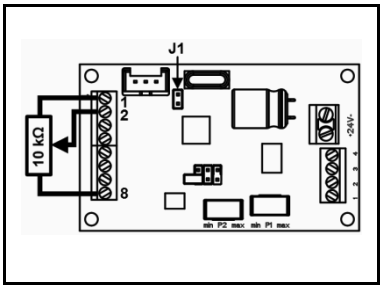

Fig. 9: External potentiometer

➔ Open jumper J1

➔ Use an external potentiometer of 1kΩ to 10kΩ resistance.
Connect the fixed terminals of the external potentiometer to COM 1 and COM 8.
Connect the adjustable potentiometer terminal to COM 2 (0 … 10 V Analogue Input)

➔ The application flow rate can now be changed by adjusting the external potentiometer

Pump type	min. flow rate [ml/min]	max. flow rate [ml/minl]
FEM 1.02	0	35
FEM 1.09	0	100

Tab. 8: flow rate range

i The flow rate may vary from pump to pump due to geometric tolerances.

i The maximum flow rate is limited by the setting of trimmer P2

➔ The pump will start at power up and it stops at power down

7.3. Controlling flow rate by analogue signal 0 – 10V or 4 - 20mA

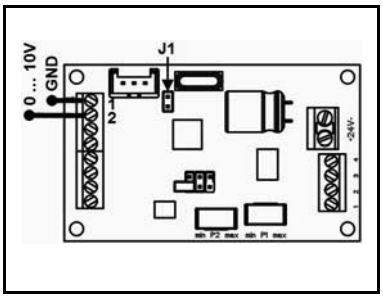

Fig. 10: Control 0 – 10V

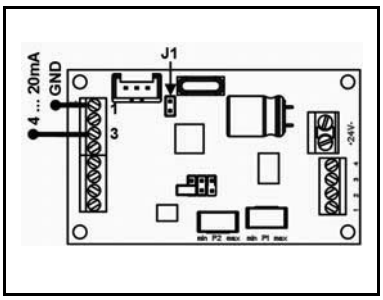

Fig. 11: Control 4 – 20mA

➔ Open jumper J1

➔ Connect the analogue signal to:
COM 2 for 0 – 10v control (see fig. 10)
COM 3 for 4 – 20mA control (see fig. 11)

➔ The flow rate is now proportional to the analogue signal applied.

i The flow rate may vary from pump to pump due to geometric tolerances.

i The maximum flow rate is limited by the setting of trimmer P2

i The signal at COM 3 (4 - 20mA) has a higher priority than the signal at COM 2 (0 - 10V) and will therefore override any connected analogue signal 0 - 10 V at COM 2.

➔ The pump will start at power up and it stops at power down

7.4. Controlling the flow rate by external Impulses, 1 impulse per micro step

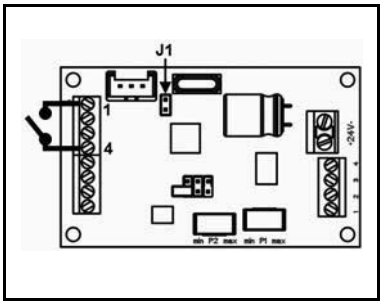

Fig. 12: Impulse control

➔ Open jumper J1

➔ For each impulse at COM 4 (Impulse Digital Input) the controller drives the stepper motor one micro step equal to 0.225° forward.
One full motor revolution equals to 1600 Impulses. That is equal to a full pump suction and pressure stroke.

i Make sure, that no analogue signals (0 … 10 V or 4 … 20 mA) are being connected at COM 2 or COM 3, while controlling the pump with the COM 4 impulse interface.

7.5. Disable / Start – Stop

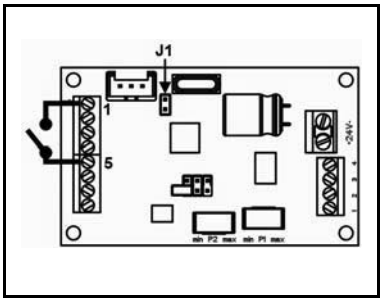

Fig. 13: Disable

➔ Use COM 5 to stop the pump operation if not implemented other ways by analog control or by cutting the DC 24V power supply.

i COM 5 connected to GND or driven to Low stops motor operation. No current is driven to the stepper motor.

i Loss of position may occur because no holding torque is applied while disabled

i This function can be used in combination with the other control signals.

7.6. Reverse

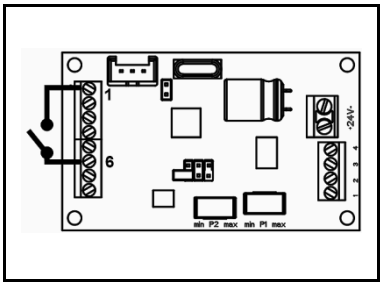

Fig. 14: Reverse

➔ Use COM 6 to reverse the direction of the motor rotation.

Continuous pump operation is not affected by the direction of motor rotation.

See section 7.8 „Applications with optional HALL position sensor advanced use“ for further use of the reverse command

7.7. Applications with optional HALL position sensor simple use

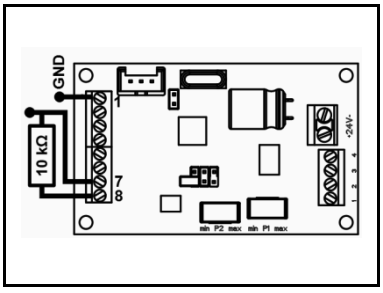

Fig. 15: HALL Open collector

The diaphragm dosing pump FEM 1.02 and FEM 1.09 can optionally be equipped with a hall sensor to get a position feedback.

The controller is equipped with an open collector output to send the signal of the HALL sensor to an external controller.

➔ Connect the hall sensor of the pump to the HALL socket

➔ Connect COM 7 of the controller to the process control unit. Note: The process control unit needs to read an open collector output.

➔ To generate a voltage signal (10V / GND) connect a 10kΩ resistor from COM 8 to COM 7 (see fig. 14).

Each passing of the middle part of a pressure stroke will then generate a short output impulse on the Hall-Output at COM 7. This results in absolute position recognition and gives the absolute position of the diaphragm inside the pump head. This offers a lot of additional pump functions like:

➔ Precise read back and process control of motor revolutions

➔ Application specific suction and pressure strokes

➔ Partial strokes for small and precise volume dosing

Precise read back and process control of an actually metered pump volume or an actually regulated pump flow rate can be implemented, while the process control values are unknown in the process. Unknown process control values can be a 0...10V signal, a 4...20mA signal, an impulse rate, and they may even be running combined with an unknown START/STOP signal. Simply read back the Hall – Output signal COM 7 and you get your process control information, like the pump motor rotation rate or the number of pump strokes.

With this capability your application can be expanded to single stroke or multiples of single stroke control for precise volume dosing. Your application can even be calibrated under real application conditions on base of a single stroke or multiples of single strokes.

7.8. Applications with optional HALL position sensor advanced use

When using the impulse control (1 impulse = 1 motor micro step) for controlling the motor speed and the motor position a lot of advanced user specific pump functions can be implemented. These functions support advanced pump applications with custom designed suction strokes and pressure strokes characteristics. Examples given:

- ➔ Fast suction strokes and slowed pressure stokes results in low pulsation volume dosing
- ➔ Slowed suction strokes and faster pressure strokes supports volume dosing to avoid degassing of liquids or cavitations.
- ➔ The output flow of a single pressure stroke is normally almost sine shaped, while the motor is driven at constant speed. The output flow of a single stroke can adjusted to an almost continuous rectangular shape by adjusting the motor speed to this behavior.
- ➔ All these user specific applications can be calibrated as well

By using the additional DIR input signal for normal/reverse direction rotation control of the motor, further applications with user designed partial suction and pressure strokes can be achieved. Each passing of the hall sensor generates a short output impulse on the Hall-Output at pin7 of the COM-connector and this is the indication that the diaphragm has reached it middle position of the pressure stroke. Any partial stroke has to be build symmetrically to this middle position. The usual procedure will be as follows:

- ➔ While moving non-reverse, stop the motor at the hall passing position, the middle point of the pressure stroke is reached.
- ➔ Go back to the start position of a partial stroke by moving reverse for N/2 micro steps.

The diaphragm is now at the start position of a partial stroke and is ready for a single partial stroke execution.

- ➔ A partial pressure stroke is executed by moving N micro steps in normal direction.
- ➔ A partial suction stroke is executed by moving N micro steps reverse.

The diaphragm is now once again at the same start position as before and a second or multiples of the same partial stroke can be executed by repeating just the last two steps.

One full motor revolution is made by moving 1600 micro steps in the same direction. This means, a full suction stroke counts 800 micro steps and a full pressure stroke counts 800 micro steps as well. If we define the suction stroke goes from position 0 to 800, then the middle part of the suction stroke will be around position 400. As a result the above value for N can go up to 800 micro steps in maximum, which is equal to a full stroke. The lower limit for N can theoretically go down to 1 micro step, which is than much lower than 1% of a full stroke volume. The real limit depends on pump tolerances and the application as well, because variations in back pressure, viscosity, temperature and more will influence this

limit. A minimum of 100 micro steps as a practical lower limit for N should work in most of the applications.

The variation of N in the range of 100 … 800 micro steps should allow to implement partial strokes volumes in the range of 20 … 100% of a full stroke volume.

These functions support further advanced pump applications with user specific designed partial strokes. These partial strokes can be executed on a single partial stroke base or as multiples as well. Examples given:

- ➔ Applications with single partial stroke capabilities, e.g. very small volume dosing
- ➔ Application with controlled multiples of a single partial stroke, e.g. small volume dosing
- ➔ Applications with custom designed suction stroke and pressure stroke on the base of a partial stroke. E.g. fast partial suction strokes and slow partial pressure stokes results in low pulsation small volume dosing
- ➔ All these user specific applications on the base of a partial stroke can be calibrated as well

8. Troubleshooting

➔ Remove the power from the controller.

➔ Check that there is no current flowing.

No pump stroke is being carried out	
Cause	Fault remedy
Controller is not connected to power supply	➔ Connect the controller to the power supply. Check for correct polarity of the PWR connector
Pump is not connected to the electronic controller.	➔ Connect the pump to the MOT connector of the controller.
Power supply is not switched on.	➔ Switch on power supply.
Electrical signal is not within the defined limits.	➔ Check the specifications (chapter 4).
Jumper J1 is not set correctly	➔ Check Jumper setting according to chapter 4.8
Controller Input channels are not connected correctly.	➔ Check Input connection according to chapter 4.6

Tab. 9

Pump motor gets hot	
Cause	Fault remedy
Too high motor phase current setting	➔ Adjust trimmer P1 to lower current setting (chapter 4.7)
Too high ambient temperature	➔ Increase airflow in the housing to stay below ambient temperature limit (chapter 4.4)

Tab. 10

Pump rattles or does not execute full cycles	
Cause	Fault remedy
Too high pump system pressure	➔ Reduce system pressure to the allowed limits of the pump
Too low motor phase current setting	➔ Adjust trimmer P1 to higher current setting (chapter 4.7)
Far too high motor phase current setting (Overheating)	➔ Adjust trimmer P1 to lower current setting (chapter 4.7)
Too high ambient temperature	➔ Increase airflow in the housing to stay below ambient temperature limit (chapter 4.4)
System valve is closed or filter is blocked.	➔ Open the valve. ➔ Clean / replace filter.

Tab. 11

Flow rate is too low, the pump rpm is too low	
Cause	Fault remedy
Setting of trimmer P2 too low	➔ Adjust trimmer P2 to the needed maximum rpm setting
Setting of Jumper J2 wrong	➔ Adjust Jumper J2 to correct RPM range
Analogue signal too low	➔ Check signal levels according to chapter 4.6.
Analogue ground not connected to controller	➔ Connect the ground of the analogue signal to COM Pin 1

Tab.12

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