WEST

Application Note: AN-105

Installation of electronic modules

Electronics
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Electronics

Content

1 Assembly instruction

1.1 Requirements

Knowledge about the application should be available. Common rules and laws, which can vary depending on the location of the installation (e.g. for prevention of accidents or environment protection), have to be considered. The technical documentation should be known/available. The work may only be done by skilled technical staff, which has knowledge about the specific engineering standards.

1.2 Surroundings

The device should not be installed nearby emitters of electromagnetic disturbance. The usage is allowed only within the protection class mentioned in the data sheet. Intended is a mounting on a DIN rail in a shielded housing like the control cabinet. Environmental conditions have to be maintained relating to the specification referring to temperature, humidity etc.
Experience has shown that a typical installation space close to the PLC in the 24V control signal range is suitable.

1.3 Further Components

Feed-in should be realized by a regulated power supply (typical: PELV system relating to IEC 60364-4-41). The low internal resistance of it offers a better diverting of noise voltage, which leads to an improved signal quality, especially when using high resolution sensors. Switching inductive reactance (relays and valve coils) at the same supply always have to get an overvoltage protection directly at the coil. If using other consumer load at the same supply a star-shaped ground wiring is recommended.

2 Mounting

2.1 General

The module has to be mounted and wired accordingly to EMC specifications. All wires which lead outwards the cabinet have to be shielded consistently. A low impedance connection between PE and the rail has to be established. Transient noise voltages are conducted from the module directly to the rail and thus to local earth. The signal wires have to be placed separately from the power lines. Ventilation slots must not be covered to ensure a sufficient cooling.

2.2 Shielding

Analog signal wires generally should be shielded. This should also be done for all other lines if their length is greater than 3 m or if there are strong sources of interference. In case of high frequency irradiation also cheap clap ferrites can be used. The shielding has to be connected to PE as near as possible to the module. The earth connections serve leading off EMC disturbances and potential equalization, means safeguarding of the functionality. They have to be connected with low impedance, this means by short wires with high cross section, to the earth potential. Of course local requirements to the shielding have to be considered.

2.3 Wire lengths

Having wire lengths of more than ten meters, the cross sections and shielding arrangements have to be evaluated by qualified personnel considering possible interferences and its sources as well as the voltage drop. For wire lengths over 40 meters particular attention is required.

2.3.1 Signal wires

When having long wirings, voltage signals can be disturbed by external influences. In this case it is recommended to use current signals in the range of 4… 20 mA. Further advantage of current signals is the possibility of monitoring them with regard to cable break.

2.3.2 Supply voltage

Typical 12 V or 24 V systems

Remark: solenoid voltage
Because of the current controlled power stage the voltage drop at the solenoid has not to be the same as the supply voltage. Typical is a lower value even at full control for having a margin when the solenoid is getting warm. In addition, the dynamic behavior of the current control is improved by the available voltage drop.

An exception to this is when overheating of the magnet in the event of a fault must be ruled out for safety reasons.

2.3.3 Solenoid wires

In the case of long cables, the significance of the impedances increases. In particular, the ohmic resistance of the cables must be taken into account when calculating the voltage drop in the solenoid circuit.

This can result in the short-circuit detection triggering with a delay or not functioning at all, because the wire becomes the main load and so the most important resistance. For example having 100 meters wire with 1.5 mm² cross section, a short cut detection is not possible anymore. Increasing to 2.5 mm² it works delayed, depending on the used solenoids and the parameterization. Further it is influenced by the used power supply and the controlled current.

The resistance of a wire can be calculated by a formula, the resulting voltage drop is proportional to the solenoid current in steady-state operation. The wire cross-section should be dimensioned according to this principle. The following approach can be used:

The specific resistance of copper is ρ = 0.0171 $\Omega mm^2/m$ at 20°C, for the temperature coefficient it can be calculated with α = 0.0039 K^{-1}. For other materials or alloys those values have to be adapted. L means the one way length of the wire to the solenoid, "A" stands for the cross section of the conductor in mm² and ϑ is the wire temperature in °C. R_L in Ω is the result representing the wire resistance.

$$R_L = \frac{\rho * \left(1 + \alpha * (\vartheta - 20)\right) * 2 * L}{A}$$

By means of this and the necessary control current to the solenoid the voltage drop of the wire can be calculated. $U = R_L * I$.

The following voltage drop each 10 m wire length can be assumed at 30°			
Cross section [mm²]	Wire resistance [Ohm]	Solenoid current [mA]	Voltage drop [V]
0.5	0.71	500	0.36
		1000	0.71
		2500	1.78
1	0.36	500	0.18
		1000	0.36
		2500	0.89
1.5	0.24	500	0.12
		1000	0.24
		2500	0.59
2.5	0.14	500	0.07
		1000	0.14
		2500	0.36
4	0.09	500	0.04
		1000	0.09
		2500	0.22

For example a 2.6 A / 3.7 Ohms solenoid can cause a voltage drop of 10.7 V in permanent operation. At a wire with a length of 50 m with 1 mm² cross section there is an additional drop of 4.45 V. The loss of the power stage can be supposed with 1 V. As result the power supply should provide a minimum of 16.2 V as the sum of the above mentioned drop values (10.7 + 4.45 + 1), this means a 12 V system is not able to drive the maximum current.

Recommendation: (2.6 A solenoid with 3.7 Ohms coil resistance in cold state)

Up to 40 m: 1.5 mm²

Up to 100 m: 2.5 mm²

The solenoid connection lines from the valve to the amplifier should be realized as 2-pin connection. A junction to the ground potential or other common potentials is not permitted. A further variation is combining the return lines for valves with only 3 connectors. The possible wiring is described in the relating documentation.
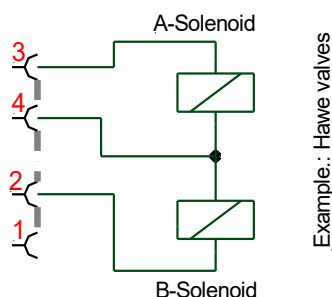
The solenoids must not be connected to recovery diodes or other semiconductors. Interruptive switching elements in those wires have to be avoided.

3 Connections

3.1 *Analog*

The analog inputs can work in unipolar as well as in differential mode, depending on the relative circuit technology, and are parameterizable for both, voltage or current signals. That can be done by DIL switches (modules without computer interface) or by a command in the WPC parameter list.

The corresponding block diagram is decisive. A unipolar input uses the circuit ground as reference potential while a differential input needs a connection of both contacts. Some devices provide a reference voltage as supply for potentiometers. The maximum load has to observed, see related documentation.

In current loops, the measurement or control value is represented by the current. This makes these loops less sensitive to interference. As a drawback is has to be considered that the signal resolution and accuracy for current signals is slightly lower than for voltage signals.
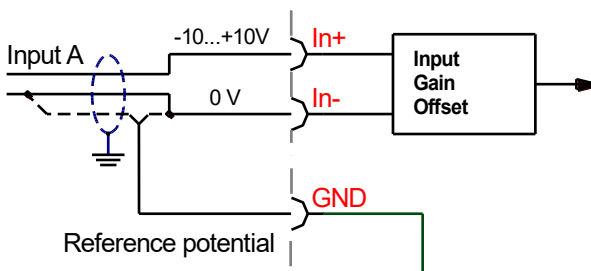
3.1.1 Voltage inputs

The analog voltage inputs are freely scalable. If using a differential input with a unipolar signal it is necessary to connect the second contact to a reference potential. For that we provide the ground potential on PIN 11, but also the potential of the signal source can be used in order to avoid line losses. A compensation is possible up to one volt.

Unipolar voltage input for 0...10V
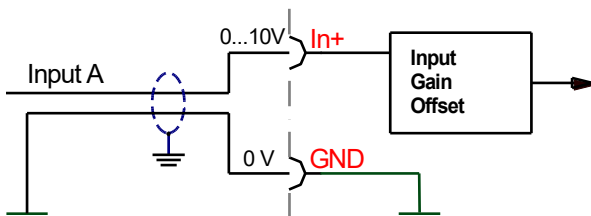
Device	In+	GND
PAM-140	K3.2	K3.4
POS-123 /-323 POS-124 / PCK-125 UHC-126 CSC-151/152/156 PID-131 PQ-132 MDR-133 PQP-176	PIN 6 Pin 13 Pin 14	Pin 11

Differential voltage input for 10V

Reference potential

Device	In+	In-	GND
PAM-199 (Function 195) SV-200	Pin 9	Pin 10	Pin 11
PAM-193	Pin 10	Pin 9	Pin 11
PQ-132	Pin 9	Pin 10	Pin 11
POS-123*	Pin 10	Pin 9	Pin 11

* Only positive values will be processed

Differential voltage input for +/- 10V

Device	In+	In-	GND
PAM-199 (Function 195) SV-200	Pin 9	Pin 10	Pin 11
PAM-193	Pin 10	Pin 9	Pin 11
PQ-132	Pin 9	Pin 10	Pin 11
POS-123	Pin 10	Pin 9	Pin 11
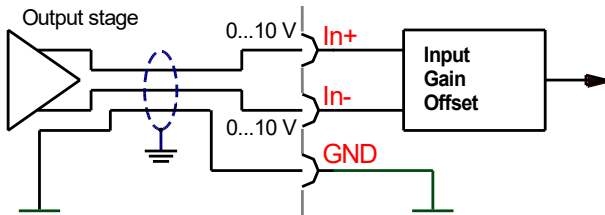
* Only positive values will be processed

Differential voltage inputs for 2 x 0...10V
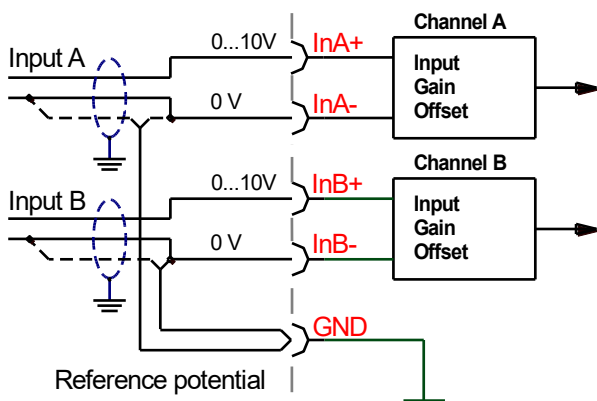
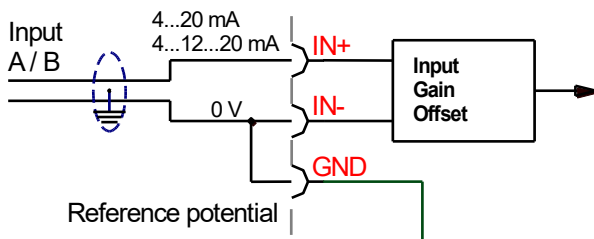| Device	In+	In-	GND
PAM-199 Ch. A (Function 196)	Pin 9	Pin 10	Pin 11
PAM-199 Ch. B (Function 196)	Pin 14	Pin 13	Pin 11
MDR-137 /-337 Ch. A Command signal	Pin 9	Pin 10	Pin 11
MDR-137 /-337 Ch. B Feedback signal	Pin 14	Pin 13	Pin 11
PQP-171 Ch. A Command signal	Pin 9	Pin 10	Pin 11
PQP-171 Ch. B Feedback signal	Pin 14	Pin 13	Pin 11

3.1.2 Current inputs

Those inputs also need a reference potential, for which the ground potential on PIN 11 should be used.
The input resistance varies depending on the module and can be found in the documentation.

Unipolar Input with 4...20 mA
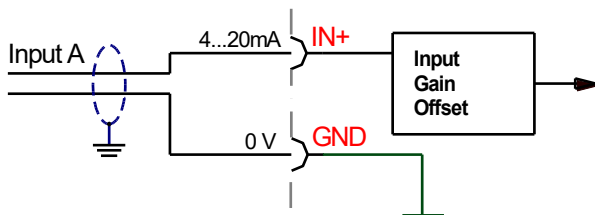
Device	In+	GND
PAM-140-P-I	K3.2	K3.4
POS-123 / -323 POS-124 / PPC-125 UHC-126 CSC-151/152/156 PID-131 PQ-132 MDR-133 PQP-176	PIN 6 Pin 13 Pin 14	Pin 11

Input 4...20 mA or 4...12 / 12...20 mA

Device	In+	In-	GND
PAM-190-P-I	Pin 2	Pin 4	Pin 3
PAM-199 (Function 195)	Pin 9	Pin 10	Pin 11
POS-123 /-323 CSC-152 PQP-176	Pin 10	Pin 9	Pin 11
DSG-111 SCU-138 PQP-171 MDR-137 /-337	Pin 9	Pin 10	Pin 11
PQP-171 MDR-137 /-337	Pin 14	Pin 13	Pin 11

Two inputs of 4...20 mA (separate Inputs)
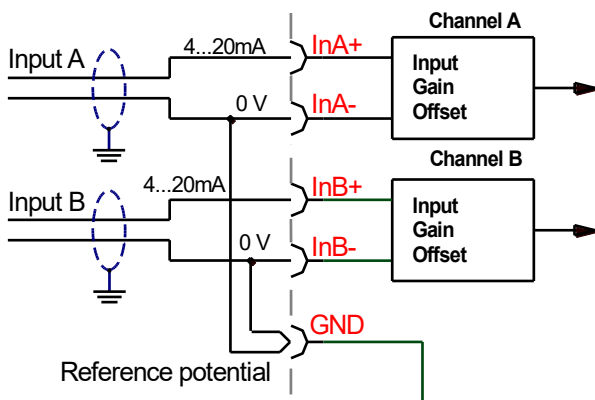
| Device	In+	In-	GND
PAM-199 Ch. A (Function 196)	Pin 9	Pin 10	Pin 11
PAM-199 Ch. B (Function 196)	Pin 14	Pin 13	Pin 11
MDR-137 /-337 Ch. A Command signal	Pin 9	Pin 10	Pin 11
MDR-137 /-337 Ch. B Feedback signal	Pin 14	Pin 13	Pin 11
PQP-171 Ch. A Command signal	Pin 9	Pin 10	Pin 11
PQP-171 Ch. B Feedback signal	Pin 14	Pin 13	Pin 11

Isolating amplifier

If several devices should receive the same signal, a universal isolation amplifier can be used to share for example the position feedback between the controller and the plc. In series connection the supply should have enough reserve voltage for the sum of voltage drops at the input resistors of module and amplifier. The inputs have to be connected to a reference potential as well (single ended). If the controller gets the signal through an isolating amplifier its dynamics and signal quality have to be considered. For closed loop controlled applications the limit frequency of the isolation amplifier should be 1 kHz or more, which is not reached by most of the standard devices.

**Electric circuit with isolation amplifier**
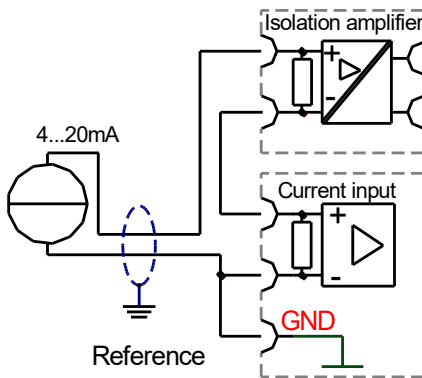
Alternative electric circuit with a high dynamic isolation amplifier
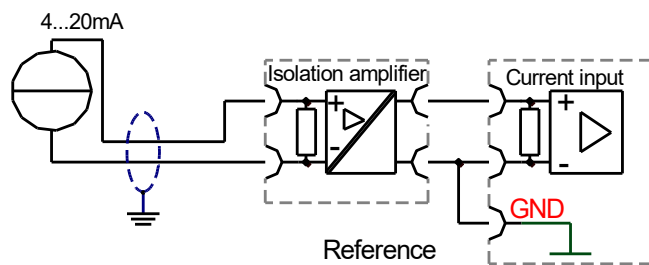
Electric circuit with several signal inputs at one current loop, special case at synchronous controller CSC-152:

In the synchronous control system using the CSC-152 modules with 4… 20mA feedback signal, several inputs can be connected in parallel, because only one input resistor is activated. This is done by parameterizing the feedback input of the master module to current. The inputs of the slave modules for acquisition the master position will be set to current as any other one by the user, but internally the input resistors are not activated. This is managed by the module's firmware without special user interaction.


System wiring of the current loop
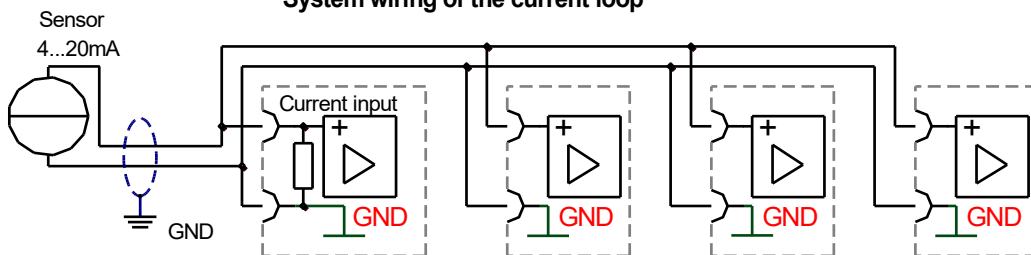
3.1.3 Connections in current loops

Sensors with analog outputs can be connected in different ways, depending on the specific sensor there may be a restriction (e.g. there are sensors which can only be used in a 2-wire system).
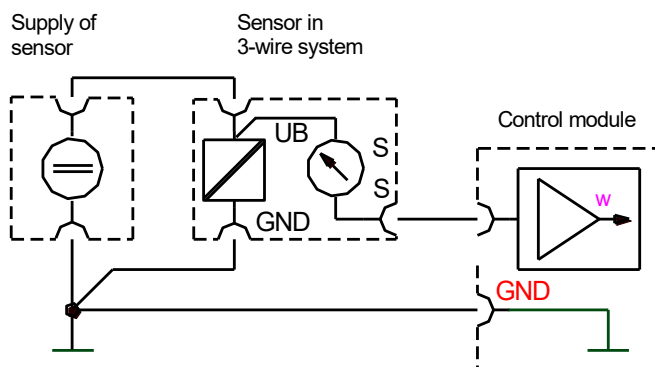
3.1.3.1 4-wire system
The supply of the sensor is done with two wires, the signal transmission as well. This requires a high effort for the wiring.
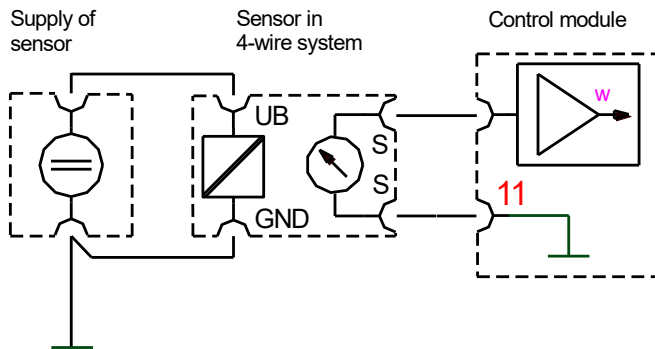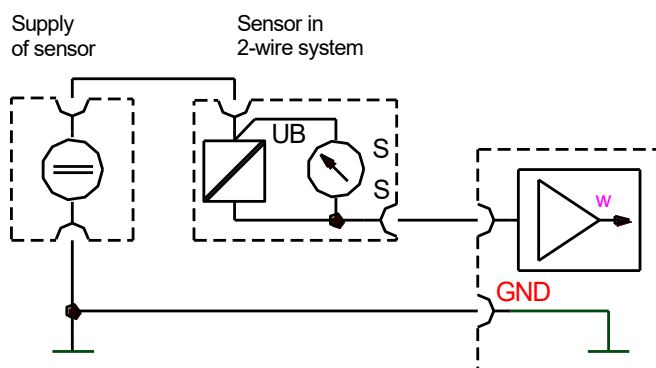

3.1.3.2 3-wire system
There are two wires for the supply of the sensor and one for the signal output. Reference potential is the common ground.

3.1.3.3 2-wire system
The sensors transfer signal and power supply via one (common) line. This is the variant with the lowest wiring effort. The sensors supply themselves via the 4...20 mA current loop.
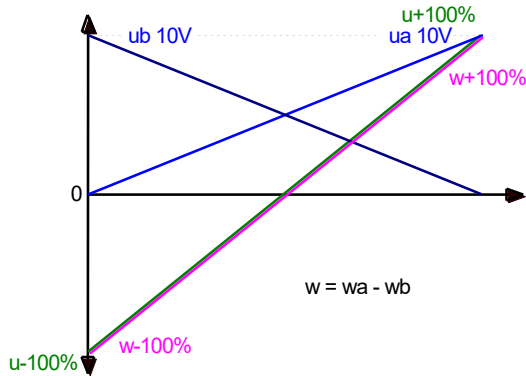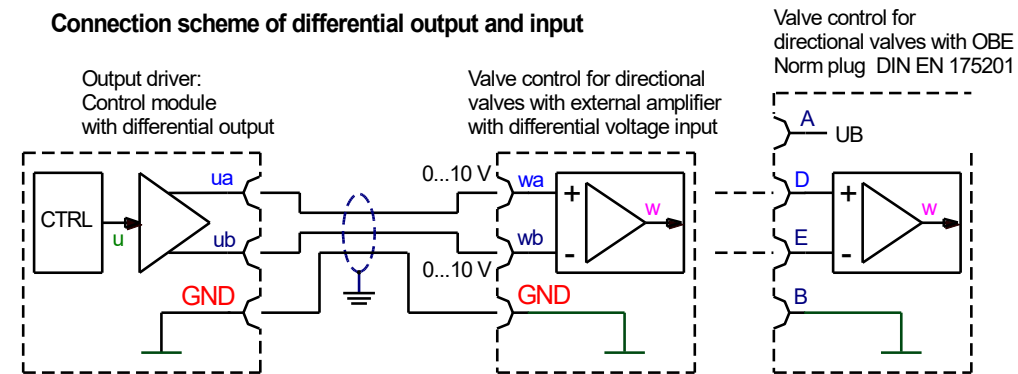
3.1.4 Voltage outputs

Unipolar outputs are used in our modules to provide analog signals related to ground potential. The outputs have a signal range of 0… 10 V with a maximum load of 10 mA.

Two of them are combined to provide a differential output.

Via differential outputs and inputs values between -100% and +100% are transmitted. The resulting signal is represented by the difference between the voltages "a" and "b". 0% means that the two voltage values are identical. The module provides 5V on both output terminals in this case, but only if the operation state is "READY". When controlling directional valves positive differential values activate direction A while negative values bring direction B into action.

Connection scheme of differential output and input

Output driver:
Control module
with differential output

Valve control for directional valves with external amplifier with differential voltage input

Valve control for directional valves with OBE Norm plug DIN EN 175201

w = wa - wb

| Device	ua	ub	GND
Module series DSG, POS, CSC, UHC, PID, PQ, PQP	Pin 15	Pin 16	Pin 12
POS-124 second output	Pin 19	Pin 20	Pin 18

3.1.5 Current outputs

If the outputs of the control modules are parameterized as current loop outputs 4...20 mA (or switched to that via DIL switch), the input on the connected component must also be set accordingly. In the "single ended" circuit of the receiver module, one side of the burden is always at GND potential.

The current loop is powered by the control module. A standardized 4 to 20 mA signal is generated by the outputs.

With this signal also both directions of a directional valve can be controlled. Hereby are 12 mA representing the neutral position. Lower values increase the activation P->B (A->T) up to 100% in direction B with 4 mA. Higher values up to 20 mA increase the activation P->A (B->T), meaning direction A (see diagram below).

Wiring scheme current loop output and input
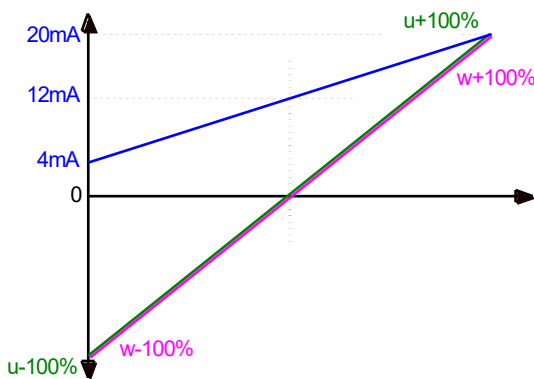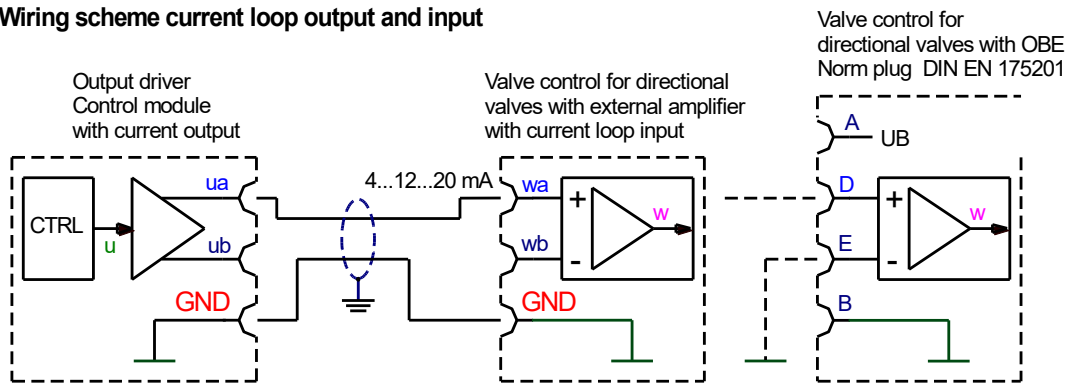
| Device	ua	GND
Module series DSG, POS, CSC, UHC, PID, PQ, PQP	Pin 15	Pin 12
POS-124 second output	Pin 19	Pin 18

3.1.6 SSI – Sensors

The Synchronous Serial Interface (SSI) is an interface for absolute encoders.

For the connection of SSI sensors twisted-pair cables should be used. This provides good shielding against interference signals. The driver of this RS422 interface allows wires of 100 meters length and more. Depending on the module, the data rate is 120 or 170 kBaud.

The real maximum wire length depends on the required clock frequency, earth potential differences between the participants and the noise which is coupled into the circuit. For that it is recommended to reduce the wire length to the necessary minimum. The type and length of the cable must guarantee the signal quality required for the specific application.

The sensor is supplied via the module. This can be connected via the same cable.
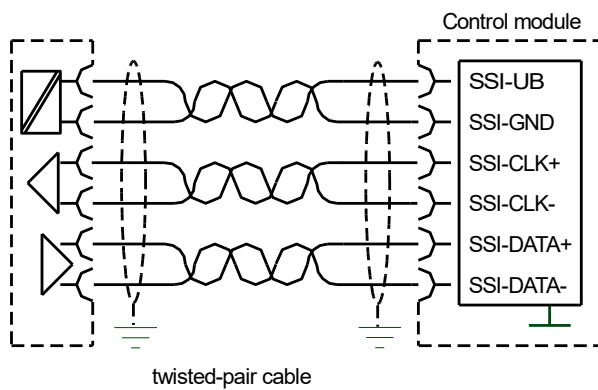
SSI	POS-123 PPC125 UHC-126 CSC-152 CSC-156	POS-124 Sensor 1	POS-124 Sensor 2
UB	Pin 31	Pin 33	Pin 47
GND	Pin 32	Pin 34	Pin 48
CLK+	Pin 25	Pin 37	Pin 41
CLK-	Pin 26	Pin 38	Pin 42
DATA+	Pin 27	Pin 39	Pin 43
DATA-	Pin 28	Pin 40	Pin 44

Control module

SSI-UB
SSI-GND
SSI-CLK+
SSI-CLK-
SSI-DATA+
SSI-DATA-

twisted-pair cable

3.2 Digital signals

The digital inputs and outputs work in such a way that the de-energized state represents a "logical zero" signal. The presence of a voltage above the minimum level corresponds to a "logical one". Accordingly, two binary states are distinguished. A range up to 30 V is covered and filters as well as reverse polarity and transient protection are provided in the device.

3.2.1 Inputs

The digital inputs have an input resistance of 25 kΩ and are detect a "logical 1" at a voltage of more than 10 V. For the reliable detection of a low level, the input voltage should be less than 2 V.
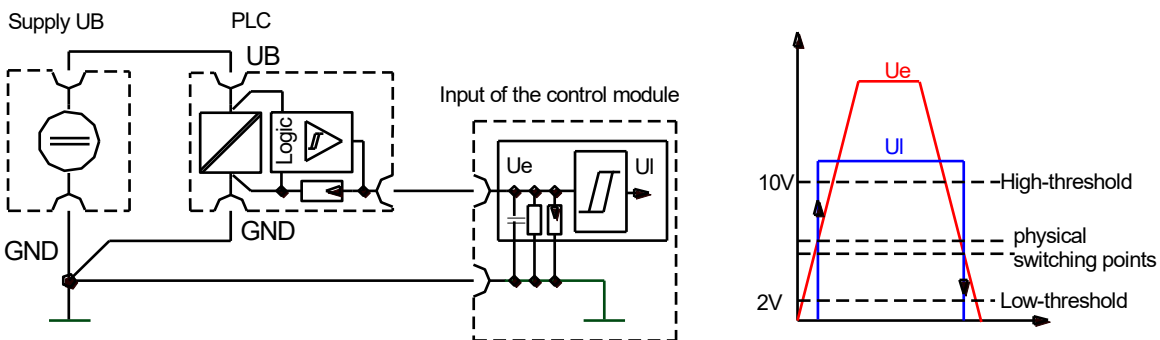

3.2.2 Outputs

The digital outputs are realized by means of an electronic switch and allow a maximum load of 50 mA. The output voltage corresponds to the supply voltage minus a maximum drop of 0.5 V.
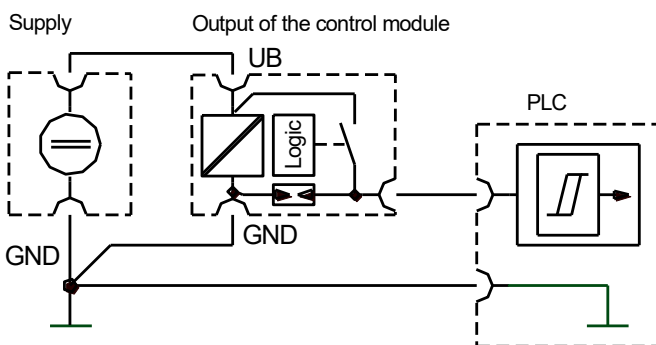
4 Principle sketch (PAM-199)

The schematical drawing shows a possible wiring of the power amplifier PAM-199-P for controlling a directional valve. Controlling unit in this system is a plc. Activation is done by the enable signal to Pin 15 and the command signal to Pin 9 and 10 of the amplifier.

The operational readiness is indicated at pin 5 of the module. Via switch S1 on Pin 6 parameterizable special functions can be controlled. The supply current to the amplifier should be limited considering the valve consumption. Depending on the power supply a fuse should be integrated in the supply line to Pin 7.
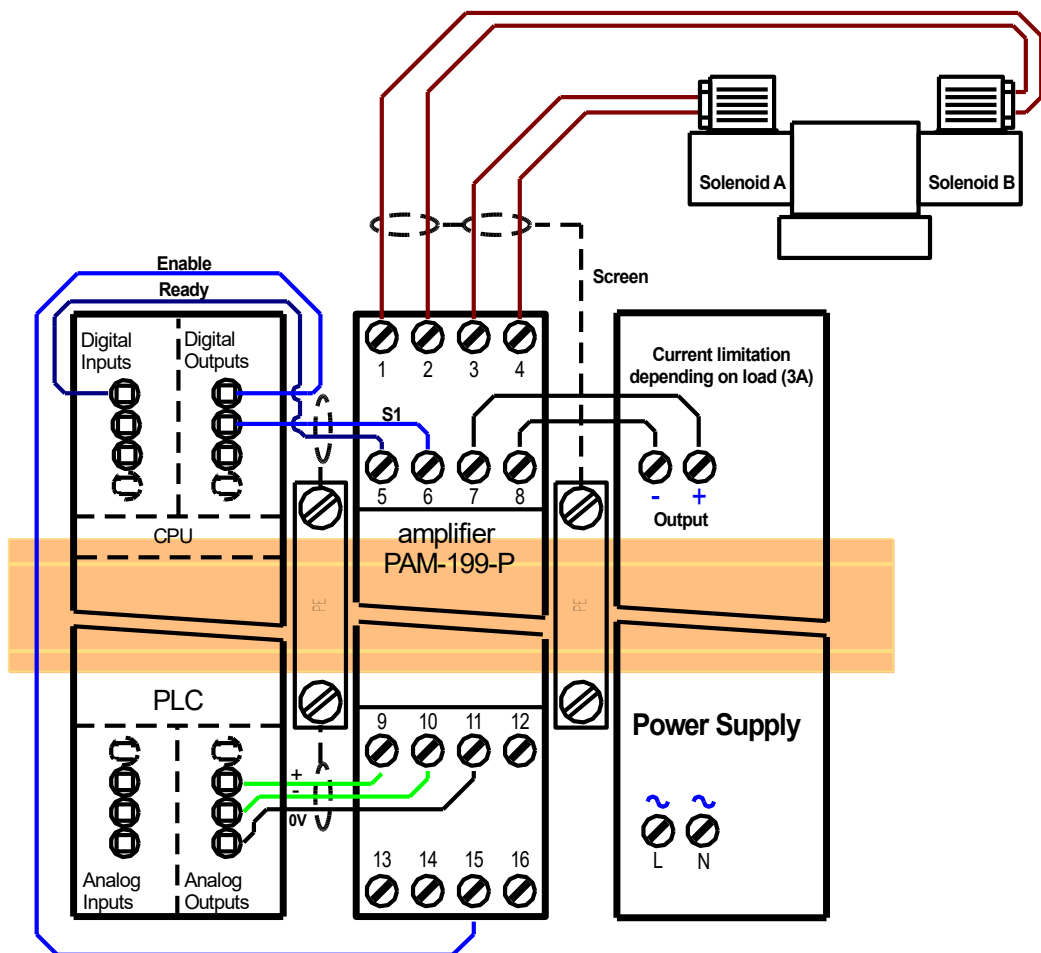
5 Imprint

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