



USER'S MANUAL

PEM-1000 ELECTROMAGNETIC FLOWMETER

PULSE OUTPUT INTERFACING

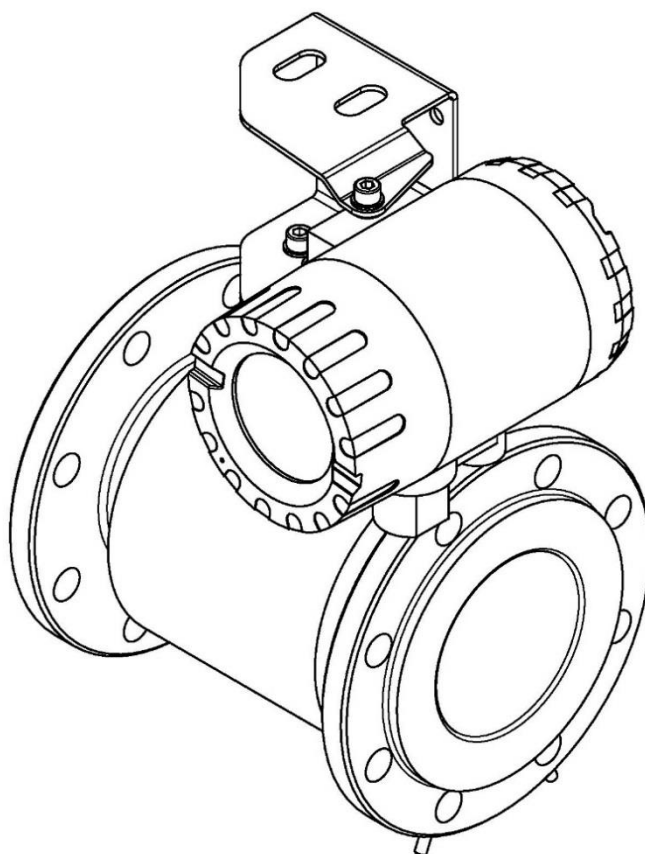


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1. INTRODUCTION

This manual covers typical scenarios of interfacing pulse output of the PEM-1000 flowmeter to various types of external input circuits and configuration of the output. The output can be used in both pulse and frequency modes, with no hardware differences.

This manual assumes, that the user has basic skills in operating the flowmeter, such as navigating the menu and entering numerical values using the local keyboard. This information is included in the Configuration manual **EN.IK.PEM.1000**.

2. ELECTRICAL CONNECTION

The pulse output terminals (5, 6) are accessible in the rear chamber of the flowmeter's case as shown at the picture below:

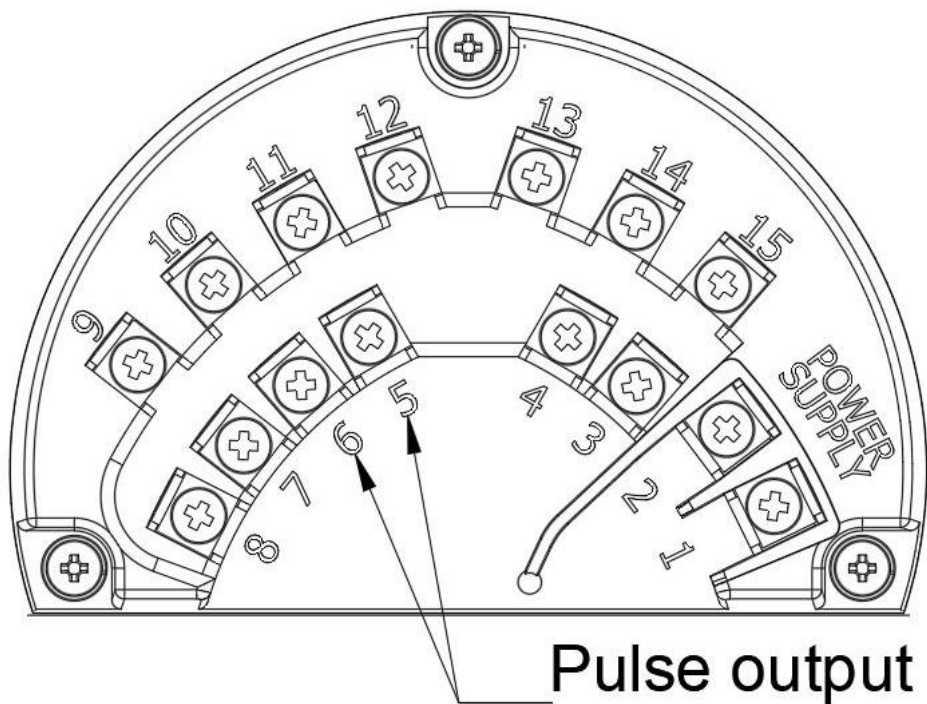


Figure 1. The pulse output terminals

Internal structure of the output will be explained, to avoid problems with interfacing to external circuits of the PLCs, test rigs' counters, pulse counters etc.

Pulse output is a galvanically isolated, passive optocoupler-like circuit, equipped with additional over-current protection and diode bridge, to allow any polarity connection. The simplified schematics of this output is as follows:

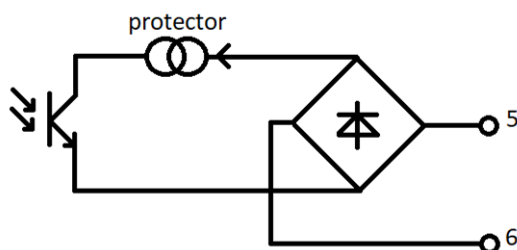


Figure 2. Simplified schematics of the pulse output

The protector circuit is low voltage drop passive current source with current limit of about 20 mA. Connecting (mistakenly) low impedance voltage source to the output is not destructible, thanks of this protection. Guaranteed output current of the output is 10 mA. The most important feature of the above circuit is voltage drop of about 1-1,5 V at the terminals 5-6. This voltage drop is higher than on-state voltage drop of standard open-collector optocoupler or relay output, which negatively affects interfacing to external circuits requiring low voltage drop output.

There are three basic cases of interfacing the pulse output to an external input circuits:

- discrete inputs with moderate detection threshold or current detection,
- passive discrete inputs with low detection threshold ($\sim 0,7$ V) intended for NPN drive,
- low voltage, active discrete inputs intended for open collector or reed (relay) contacts only.

Inputs with moderate detection threshold are typically active current sources with current detection circuits or voltage type inputs, optionally with active polarization circuits powered internally from voltages not less than 5 V. Typical examples of those inputs are digital inputs circuits of PLC controllers, test rigs' input circuits, galvanically isolated interfaces etc. Typical threshold voltages lie in the range of 5-20 V with significant hysteresis. Typical threshold current is about 1-5 mA. Inputs with polarization circuits can be directly interfaced to the pulse output. See drawing below:

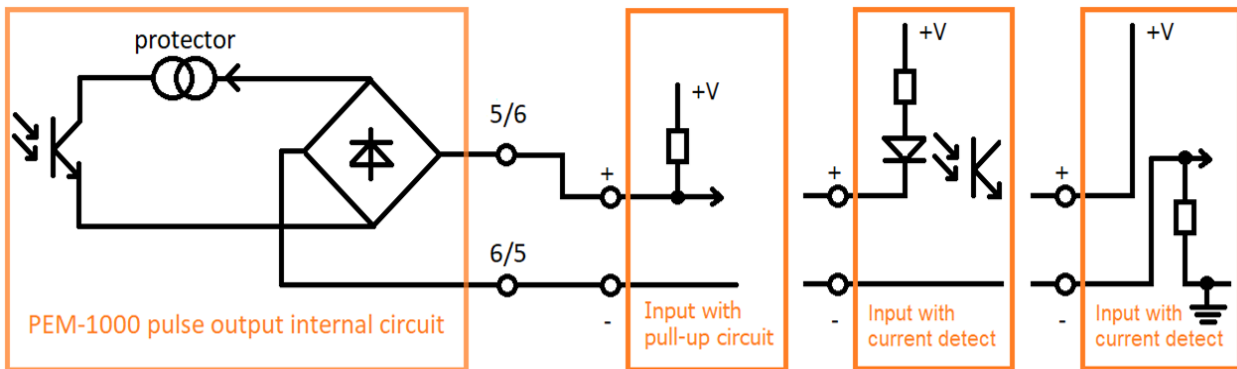


Figure 3. Connecting of the external inputs with polarization circuit

Inputs without polarization circuit should be interfaced with the help of external power supply. See drawing below:

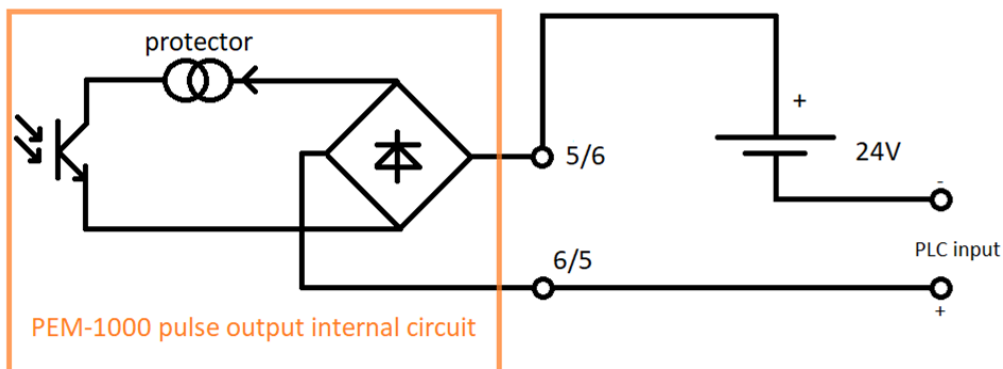


Figure 4. Connecting of the external inputs without polarization circuit

Please note, that some of the proposed circuits may require power supply of about 24 V. It could be any accessible 24 V source, e.g. local 24 V mains, power supply of the low voltage version of the flowmeter etc., due to galvanic insulation on the flowmeter's side. Also, typical industrial-grade PSU can be used, advisably as small as possible, because current drawn by these circuits are very small.

Passive inputs with low detection threshold are typically intended to drive NPN outputs. Their maximum operating voltage is about 30 V, but the threshold voltage is about 1 V. Those circuits cannot be directly interfaced to the pulse output of the flowmeter, but can be used in “PNP” mode. Simple interfacing circuit resolves this issue. See drawing below:

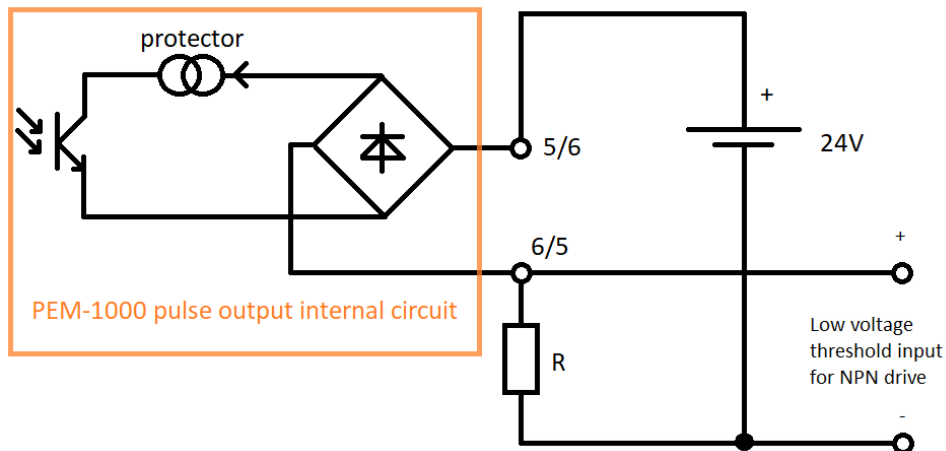


Figure 5. Connecting of the passive input with low detection threshold intended for NPN drive

Value of R resistor is not critical, it should be anywhere in the range 2,2-22 kΩ. The higher the resistance, the smaller current drawing from power supply, but also the lower noise immunity of the circuit.

The most troublesome are low-power, low-voltage active digital inputs intended only for potential-free contacts such as relay, reed or open collector ones. Typical examples of those inputs are low power devices such as LCD pulse counters, heat meters or other devices based on low voltage logic. In this case the following circuit should be used:

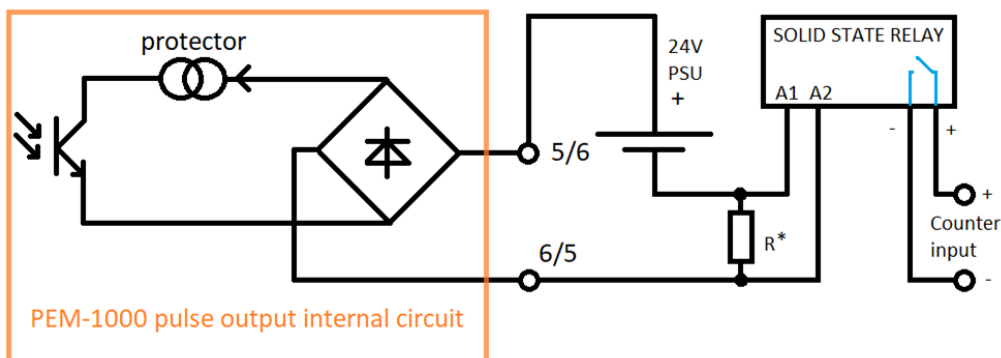


Figure 6. Connecting of the low-voltage active discrete inputs intended for potential-free contacts

The circuit uses solid state relay (SSR). For this task **only** versions with low on-state voltage drop, low output leakage current and low minimum working current are suitable, because input circuits of low voltage devices typically source currents in range of 1-2 mA and detection threshold voltage is less than 1 V. ELCO SSR20-524C is well suited for this task. The parameters of this device are shown in table below:

Table 1. Main parameters of the ELCO SSR20-524C

Parameter	Load voltage	Output voltage drop (ON state)	Off-state leakage current	Minimum working current (ON state)	Input voltage range	Input current
Value	0-35 V DC	300 mV	10 μA	1 mA	10-32 V DC	3,2-13 mA

Resistor R is optional in this circuit (used only for high sensitivity SSRs). Any equivalent SSR of similar parameters can be used. Please note, that this SSR has polarized output and non-polarized input. Observe polarities for equivalent parts. For complete part list of this circuit see → [Appendix A. Part list for output interface circuit for reed contact inputs](#). For SSR equivalents see → [Appendix B. SSR equivalents](#).

Some versions of low-power low-voltage digital inputs cannot be driven even by a SSR relay because of extremely low driving current (in the range of μ Amperes) together with low detection threshold and high input impedance. Typical examples of those inputs are battery-powered low power devices, such as LCD counters and energy meters (e.g. Zenner multidata series). Fortunately, these inputs can often be controlled by an active low voltage source. Driving of these inputs requires slight modification of the PNP schematic:

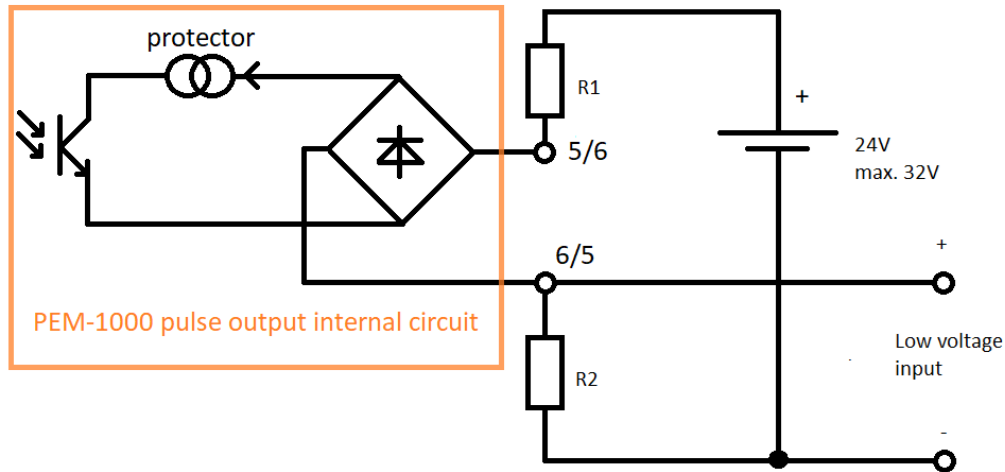


Figure 7. Connecting of the discrete inputs with extremely low driving current (in the range of microamperes)

Resistors R1 and R2 form a voltage divider protecting input circuits against an excessive voltage from 24 V source when pulse output is active. For maximum input voltage of low-voltage input of 3,6 V, resistor values should be: R1 = 12 k Ω , R2 = 1,5 k Ω for 24 V power supply, providing it is not exceeding 32 V. Power supply units of other voltages can be used, then the resistors values must be calculated according to power supply voltage and voltage limits of the input circuit. See [Appendix C. Low voltage active driver calculations](#) for calculations for other cases.

3. CONFIGURATION OF THE PULSE OUTPUT

3.1. Pulse mode

The pulse output in pulse mode of the flowmeter must be properly configured to achieve the best resolution and avoid errors stemming from too high pulse frequency. The most important parameters are pulse length and volume per pulse (VPP). These parameters are self-explanatory – for each complete volume unit of VPP one pulse of chosen length is issued. Please note, that PEM-1000 flowmeter uses “volume per pulse” approach, but some flowmeters or pulse detection devices use “pulses per volume” approach, those parameters are reciprocals of each other. That is why using round numbers as a VPP parameter (or checking its reciprocal) is recommended.

Theoretical maximum instantaneous pulse frequency for pulse output is 500 Hz, because the shortest pulse is of 1 ms and the shortest gap is also of 1 ms. Such high frequencies should be avoided because of risk of pulses loss in case of temporary flow rate peak. Also, SSR frequency limits and external circuit frequency limits apply. Theoretical limits for VPP value and pulse length result from the formula below:

$$\frac{Q_{MAX}}{VPP [m^3] \cdot 3600} < \frac{1000}{pulse\ time [ms] + 1}$$

where Q_{MAX} – maximum flow rate [m³/h].

Setting proper values of pulse output parameters requires some margins. That is why optimal output frequency for 100% of range should be no greater than about 200 Hz for 1 ms pulses.

The pulse length should be set to satisfy detection capabilities of external circuits. Practical values fit in the range 1 ms (fast inputs) – 100 ms (very slow inputs). Value used should be as low as possible, because it limits maximum achievable frequency. The longer pulse length, the lower the maximum theoretical frequency – for 10 ms pulses it drops to ~90 Hz.

Typical configuration of pulse output is as follows:

- Menu → Configuration → Outputs → Pulse output → On/Off = ON,
- Menu → Configuration → Outputs → Pulse output → Mode = PULSE,
- Menu → Configuration → Outputs → Pulse output → Pulse → Pulse time = 1[ms] (see notes above),
- Menu → Configuration → Outputs → Pulse output → Pulse → Mode = POSITIVE,
- Menu → Configuration → Outputs → Pulse output → Pulse → Polar = POSITIVE,
- Menu → Configuration → Outputs → Pulse output → Pulse → Volume / imp. = (see explanation above).

Please note, that filtering setting “for pulse output” (Menu → Configuration → Filtering → for Pulse out) regards frequency mode of the output. There is no filtering available for pulse output in pulse mode, because of self-averaging and high-precision nature of this mode of operation.

3.2. Frequency mode

The pulse output in frequency mode (hereinafter referred to as frequency output) calculates the current frequency according to a linear formula:

$$f_{out} = Q \cdot A + B$$

The A and B coefficients are calculated internally after each change of the output configuration, based on the flow values given in the menu, in such a way that the maximum output frequency of **2000 Hz** corresponds to the entered upper flow rate value (Q_H), and the minimum frequency of **1 Hz** corresponds to entered lower flow rate value (Q_L). Therefore, the A coefficient is calculated assuming the working frequency range is $f_{max} - f_{min}$, i.e. 1999 Hz. The frequency of 1 Hz is the minimum that can be obtained at the output, if the formula shows $f_{out} < 1$ Hz, the output is in 0 state. This is protection against operation at very low frequencies.

The output changes frequency after receiving the next measured flow rate value, which occurs approximately every 0,5 s. The frequency values that can be obtained are discrete values (due to the way the waveform is generated), however, the resolution of the output is sufficient for typical applications. The output works with buffering, i.e. it switches to a new frequency after the end of the last full waveform period calculated on the basis of the previous measurement. Thanks to this, the duty cycle of the output waveform is a constant value of 50%.

The frequency output serves the same purpose as the 4-20 mA current output, i.e. to represent an instantaneous (filtered or unfiltered) flow rate value. Due to the lack of precise mechanisms for controlling the number of pulses, it is not intended for measuring liquid volumes (although it may be useful for this purpose, discussed below). The pulse mode of output is intended for precise volume measurement.

In a typical, simplified case, the upper value is given as a range value ($Q_H = Q_{max}$), and the lower value is set to zero ($Q_L = 0$). Consequently, the B coefficient takes the value of 1, which means that at zero flow rate (also in the event of an error) the output frequency is 1 Hz, and for half of the range (50% Q_{max}) the output frequency is 1000,5 Hz.

As mentioned above, the frequency output **does not have a separate error signaling mechanism** (like the 4-20 mA output), it responds only to the Q value, and the error handling is based on the fact that in the event of its occurrence, the value $Q = 0$ is forced. Another disadvantage of the $Q_L = 0$ approach is that it is not possible to easily convert the number of pulses issued by the output into the volume of liquid, which means that the frequency output cannot operate in the volume measurement mode (this is due to the fact that $B = 1$). In such a situation, the number of pulses L is:

$$L = V [m^3] \cdot \left(A + \frac{B}{Q_{avg} [m^3/h]} \right) \cdot 3600 = V [m^3] \cdot \left(\frac{1999}{Q_{max} [m^3/h]} - \frac{1}{Q_{avg} [m^3/h]} \right) \cdot 3600$$

and, as you can see, it depends on the average flow rate value, which is usually not precisely known.

To fully use the capabilities of the frequency output, **it is recommended to configure it so that the zero flow rate value corresponds (virtually) to a frequency of 0 Hz**. Of course the output will cut off frequencies below 1 Hz, however the ideal transient characteristic will cut at the point [0 Hz, 0 m³/h] (since B = 0). To achieve this, set the lower value as:

$$Q_L = \frac{Q_H}{2000}$$

In this situation, you can easily determine the number of pulses corresponding to the volume of flowing liquid (assuming $Q_H = Q_{max}$):

$$L = \frac{V [m^3]}{Q_{max} [m^3/h]} \cdot 2000 \cdot 3600 = \frac{V [m^3]}{Q_{max} [m^3/h]} \cdot 7,2 \cdot 10^6$$

Sometimes it is important to establish the relationship between the output in pulse and frequency mode. You can try to determine the relationship between the VPP value configuring the pulse mode and the Q_H value configuring the frequency mode:

$$VPP = \frac{Q_H [m^3/h]}{7,2 \cdot 10^6}$$

Again, it is worth mentioning that some programs that use pulse or frequency output, use the opposite notation to VPP, i.e. the number of pulses per given volume. For example, the concept of “pulse constant” expressed in the unit of 1/dm³ is used. This constant is related to VPP and the upper flow Q_H by the relationships:

$$Pconst \left[\frac{1}{dm^3} \right] = \frac{1}{VPP[m^3]} \cdot 1000 = \frac{7200}{Q_H[m^3/h]}$$

however, in the case of a frequency output, remember to use the formula $Q_L = \frac{Q_H}{2000}$.

4. HISTORY OF REVISIONS

Revision No.	Document revision	Description of changes
-	01.A.001/2024.02	First version of the document. Prepared by DBFD, DR.
1	01.A.002/2024.03	Added configuration of the pulse output in frequency mode. Prepared by DBFD, DR.

Appendix A. Part list for output interface circuit for reed contact inputs

Description	Manufacturer	Part number	Notes
SSR	ELCO	SSR20-524C	
SSR socket	Relpol	GZ80	
PSU 24V	Meanwell	HDR-15-24	

Appendix B. SSR equivalents

Please note, that the equivalent of the SSR used in the interface circuit should be chosen with great care, most of the SSR's do not meet the requirements of low-power, low-voltage input circuits. SSRs based on thyristor/triacs or bipolar transistors with reverse polarity protection may not be usable due to their elevated voltage drop or minimum load current values. The following parts were chosen, according to their catalog specifications, but were not tested at the field. All of them are SPST-NO version, which is also the most popular. Packaging of these parts may not be compatible, please use relevant sockets for TH35 rail mounting.

Crydom DRA-CN024D24, 500Hz max. or CN024D24 (PCB mount mini version)						
Parameter	Load voltage	Output voltage drop (ON state)	Off-state leakage current	Minimum working current (ON state)	Input voltage range	Input current
Value	0-24 V DC	400 mV	1 μ A	1 mA	15-30 V DC	5,6-11,2 mA 4,3-8,6 mA*

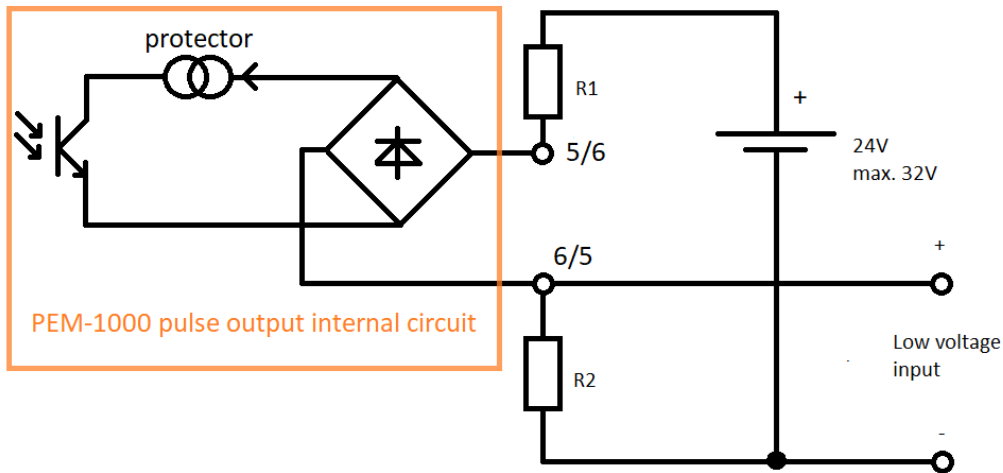
*) for CN024D24 PCB mount mini-SIP version

Phoenix Contact OV-24DC/60DC/4 - 2982647, 100Hz max.						
Parameter	Load voltage	Output voltage drop (ON state)	Off-state leakage current	Minimum working current (ON state)	Input voltage range	Input current
Value	0-24 V DC	400 mV	1 μ A	1 mA	4,25-32 V DC	5,6-11,2 mA

IDEC RV8S-L-D24-D24 or RV8S-S-D24-D24						
Parameter	Load voltage	Output voltage drop (ON state)	Off-state leakage current	Minimum working current (ON state)	Input voltage range	Input current
Value	0-24 V DC	400 mV	1 μ A	1 mA	19,6-30 V DC	not listed

Appendix C. Low voltage active driver calculations

Some low-voltage digital inputs can be driven by active voltage source, providing that maximum input voltage is not exceeded. Schematics of the connections is as follows:



Resistors R1 and R2 form a voltage divider limiting maximum output voltage of the driver. Calculated values of these resistors for some typical cases are as follows (E series values are used, recommended tolerance is 1%):

Power supply voltage	Maximum input voltage	R1	R2
24 V (max. 32 V)	3,6 V	12 kΩ	1,5 kΩ
24 V (max. 32 V)	3,3 V	24 kΩ	2,7 kΩ
24 V (max. 32 V)	5 V	12 kΩ	2,2 kΩ
12 V (max. 16 V)	3,6 V	5,1 kΩ	1,5 kΩ
12 V (max. 16 V)	3,3 V	5,6 kΩ	1,5 kΩ
12 V (max. 16 V)	5 V	4,7 kΩ	2,2 kΩ

For other values of these parameters, follow the formula below:

$$\text{max. power supply voltage} \cdot \frac{R2}{R1 + R2} \leq \text{max. input voltage}$$