Application Note: AN-102

Control of proportional valves in potentially explosive areas

POS-123-P

and optional for our various power amplifiers

Electronics
Hydraulics meets
meets Hydraulics
Electronics

Contents

1 Explanation of the problem

Some proportional valves are available on the market today and can be operated in potentially explosive atmospheres. Together with explosion-protected position measuring systems, it can be used to implement electro-hydraulic positioning drives.

There are two options for the electronic control of these drives:
- (Power-) Electronics in Ex-area as OBE on the valve
- The electronics are located in a safe zone and are connected to the valve coils via possibly longer cables, or they are located in an explosion-proof switch box on site.

There are some arguments against the first variant:
- Maintenance and adjustment on site is more difficult than when installing in a control cabinet, especially for explosion-protected devices. Possibly the mounting position is also difficult to reach with programming devices.
- The on-board electronics are always paired with a manufacturer's valve. The system integrator loses the flexibility to use different manufacturers alternatively or has to familiarize himself with a new system every time.
- Most of the time, the OBE does not include any positioning control for the Ex area and a further module is necessary anyway.
- OBE electronics are exposed to increased temperature loads, which can reduce the service life.
- Vibrations and shocks can represent additional, avoidable loads.

For these reasons, the use of remote electronics including a power amplifier is highly recommended, especially in Ex areas. However, there is the following aspect that must be observed:

The valves that can be used usually have the protection class EX d. This means that appropriate pressure-tight encapsulation prevents explosions from being triggered. The energy in the electrical control circuit therefore does not have to be limited, as is the case with type of protection EX i.

It is also important that the surface temperature of the coils must not exceed the value permitted for the respective temperature class. Otherwise, explosions could ignite on the hot surface.

The valve manufacturers offer products for different temperature classes in different explosion protection zones. However, it is a prerequisite that the nominal current or alternatively the nominal voltage is observed, since the heating of the coil can exceed the limit values at higher values.

If you want to bridge a longer line between the electronics and the valve, or if higher control dynamics are required, then solenoid coils with a lower nominal voltage (in relation to the supply voltage) can be used so that the voltage drop on the line does not cause any problems.

Coils which are designed for a voltage of e.g. 12 V can be operated well over longer distances if the supply voltage of the output stage is 24 V.

In normal operation, the current from the power output stage is limited to the value set there, so there is no risk of overheating.

However, errors must also be considered and a suitable protective measure defined. Here this would be a short circuit in the output stage of the power amplifier.

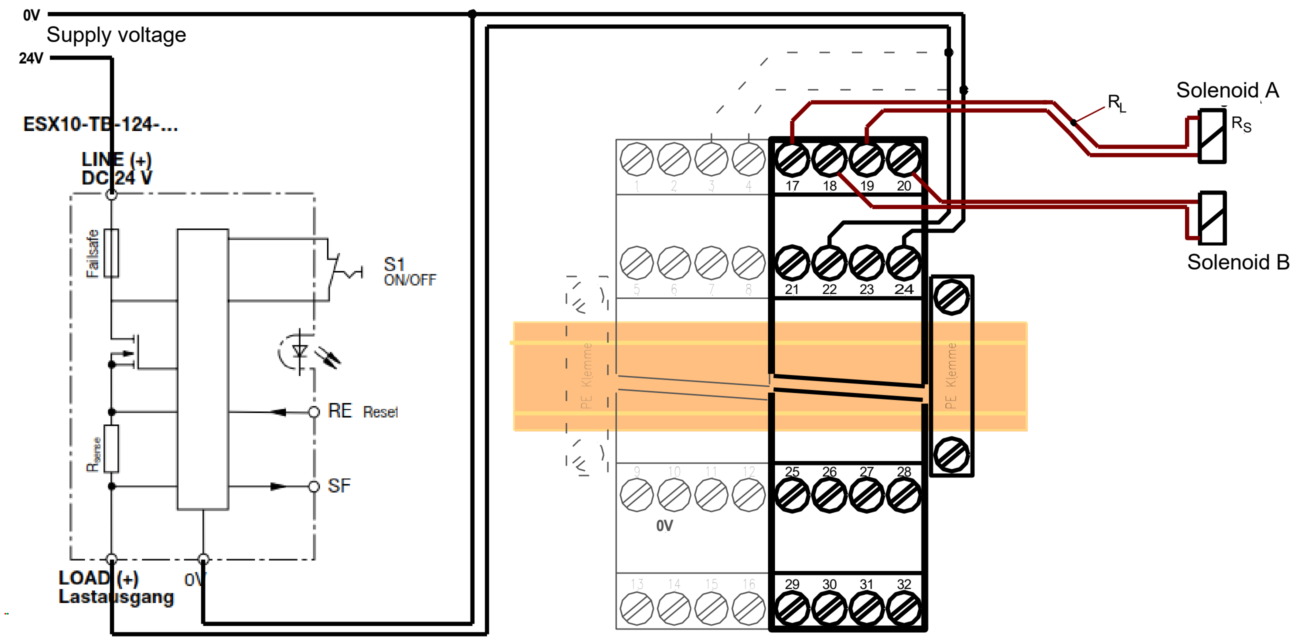
The task is therefore to define and design a protective measure which, in the event of an error, switches off and in normal operation does not restrict the function.

2 Realisation / circuit diagram

For the overcurrent protection required here, it is best to use an electronic fuse that is designed for DC in the area of the supply voltage.

The ESX10-T.-DC 24 V series from E-T-A, for example, is well suited. It is important to choose a circuit breaker that correctly processes the pulsating current consumption of the PWM power amplifiers and that has the lowest possible tolerance for the switch-off current. Fuses or thermal circuit breakers are therefore not recommended.

The following illustration shows the system structure when using the above-mentioned device:



As shown here, the control section of the POS-123-P can also be supplied at terminals 3/4 via the device or can be protected separately.

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3 Design

1.) Line resistance or cross section for a given length
2.) Required nominal current of the circuit breaker

First, the resistance of the solenoid leads must be determined. For short connections, a rough recalculation is sufficient. If the supply lines are longer, the maximum resistance required for the function must be first determined.

In most cases, only cold resistances are specified for the coils; these may also have to be requested from the supplier[1]. When heated, the resistance increases by a factor of 1.57 according to this equation:

$R_{S,hot} = R_{S,cold} \cdot (1 + \alpha \cdot \Delta T)$, with α = 0,00393 for copper.

165 °C are used as the mean coil temperature. This value is intended to serve as an upward estimate. If manufacturer information is available, this should be used.

In extreme case it is: $R_{sum} = 2 \cdot R_L + R_{S,cold} \cdot 1{,}57$ (1)

It follows: $R_{L,max} = \frac{R_{max,sum} - R_{S,cold} \cdot 1{,}57}{2}$ (2)

To ensure that the full current can flow even when the coil is warm, a PWM pulse duty factor of 95% should now be taken into account. It is therefore:

$R_{Max,sum} = U_B / (I_{nominal} \cdot 0{,}95)$ (3)

A calculation example:

- *Nominal current of the coil for proportional operation 2,6 A*
- *supply voltage 24 V*
- *Coil resistance (cold) 3 Ohms*

It follows from the nominal current and the supply voltage: $R_{Max,sum} = 24V/(2{,}6A \cdot 0{,}95) = 9{,}72\ \Omega$

By inserting into equation 2 follows: $R_{L,max.}$ = $2{,}5\ \Omega$

A suitable cross-section must then be selected for longer cable lengths so that the value calculated here is not exceeded.

Caution: Despite large cross sections, a shielded cable must be used in any case (EMV)!

Example: The cable length is 200 m. If you choose a cross-section of 2.5 mm², the resistance for a typical cable is 1.6 ohms. This is sufficient in terms of function.

Nominal current of the device:

It is important that a trip occurs in the event of a short circuit. With the selected line resistance and the given coil data, a recalculation must now be carried out. Any possible undervoltage must also be taken into account.

$I_K = \frac{U_B}{R_{S,cold} \cdot 1{,}57 + R_{L,chosen} \cdot 2}$ (4)

In example: I_K *= 3,03 A.*

The tolerance range of the overcurrent shutdown is shown in the data sheet of the device. The nominal current is to be selected so that it is as high as possible but so low that a reliable tripping takes place in the event of an error.

[1] A calculation according to Ohm's law from the information for nominal current and voltage or power information is not possible

In example: An E-T-A ESX10-TB is to be used. The data sheet states that the overload shutdown occurs at a maximum of 1.35 x IN. The 2A variant is therefore suitable.

At this point, it may be necessary in other cases to reduce the line resistance again in order to achieve safe triggering of the circuit breaker.

It is noticeable that the tripping current of the overload protection in the example is less than the nominal current of the magnet. This is not a problem in normal operation, because the power output stage together with the magnet represents a buck converter that transforms the input power to the lower magnet voltage with little loss. This means that the input current is lower than the solenoid current.

In the example considered here, the theoretical input current for a cold coil and nominal coil current is 1.75 A.

Under extreme conditions, especially a warm coil and a low supply voltage, it is quite possible that the tripping current of the machine is reached.

This would result in the position control loop failing.

4 Required measure in the control module

To avoid false triggers and to guarantee the availability of the application in any case, the POS-123-P has a function to limit the maximum input current consumption (parameter IMS, see instructions for the module). This does not limit the dynamics of the system and the full solenoid current is maintained as long as possible.

This function is unique and enables the safe operation of proportional valves in Ex areas, even in combination with long supply lines.

By implementing the safety function in the upstream circuit breaker, an "overload or overtemperature protection device" is provided in the sense of ATEX. The device proposed here has corresponding certificates.

The power amplifier or the positioning module itself is not a safety device, but its function is optimally coordinated with the characteristics of the circuit breaker.

In this way, a standard-compliant implementation of the overload protection is ensured with minimal effort.

The new input current limiting function can also be integrated into power amplifiers on request.

5 Imprint

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