

Electrohydraulic controls: commissioning and trouble shooting

The following notes give some general suggestions and cautions on the procedures to ensure the good operation of an electrohydraulic system, with particular reference to the closed-loop circuits, typical of modern electrohydraulic axes and of high-performances proportional components with integral analog and digital electronics. For more detailed information about specific components see the relevant technical tables. For proper operation of electrohydraulic components, following prescription must be respected.

1 HYDRAULIC SECTION

- 1.1 Tank and tubes cleaning
- 1.2 Connections
- 1.3 Filtration
- 1.4 Hydraulic drains and return lines
- 1.5 Hydraulic fluid
- 1.6 Fluid conditioning
- 1.7 Air bleeds

1 HYDRAULIC SECTION

1.1 Power packs tank and tubes cleaning

Power unit tank has to be accurately cleaned, removing all the contaminants and any extraneous object; piping has to be cold bended, burred and pickled. When completely assembled an accurate washing of the piping (flushing) is requested to eliminate the contaminants; during this operation the proportional valves have to be removed and replaced with by-pass connections, or on-off valves.

1.2 Hydraulic connections

The flexible hoses have to be armoured type on pressure line between powerpack and proportional valve and on return line from proportional valve. If their potential breackage may cause damages to any machine or system or can cause injure to the operator, a proper retention (as the chain locking at both the pipe-ends) or alternately a protecting carter must be provided.

The proportional valve must be installed as close as possible to the actuator, to assure the maximum stiffness of the circuit and so the best dynamic performances.

1.3 Hydraulic fluid

Use only good quality fluids according to DIN 51524..535, with high viscosity index. The recommended viscosity is $15 \div 100 \text{ mm}^2/\text{sec}$ at 40°C . When fluid temperature exceeds 60°C select viton seals for components; in any case the fluid temperature must not exceed 80°C .

1.4 Fluid filtration

The fluids filtration prevent the wearing of the hydraulic components caused by the contaminants present in the fluid.

Fluid contamination class must be in accordance to ISO 18/15 code by mounting in line pressure filter at $10\mu\text{m}$ value and $\beta_{10}=75$.

In line filters must be mounted, if possible, immediately before proportional valve; the filtering element is high cracking pressure type with clogging electrical indicator, without by-pass valve.

The flushing (at least 15 min. long) has to be performed at the system commissioning to remove the contaminants from the whole circuit.

After this operation filtering elements and flushing accessories cannot be used again, if clogged.

Following additional warnings to be considered:

- make sure that the filters are of correct size to ensure efficiency;
- the main source of contamination of an hydraulic system is the air exchanged with

2 ELECTRONIC SECTION

- 2.1 Power supply
- 2.2 Electrical cabling
- 2.3 Suppression of interferences by electrical noise
- 2.4 Use of the service signals
- 2.5 Electronic calibrations
- 2.6 Temperatures and environments

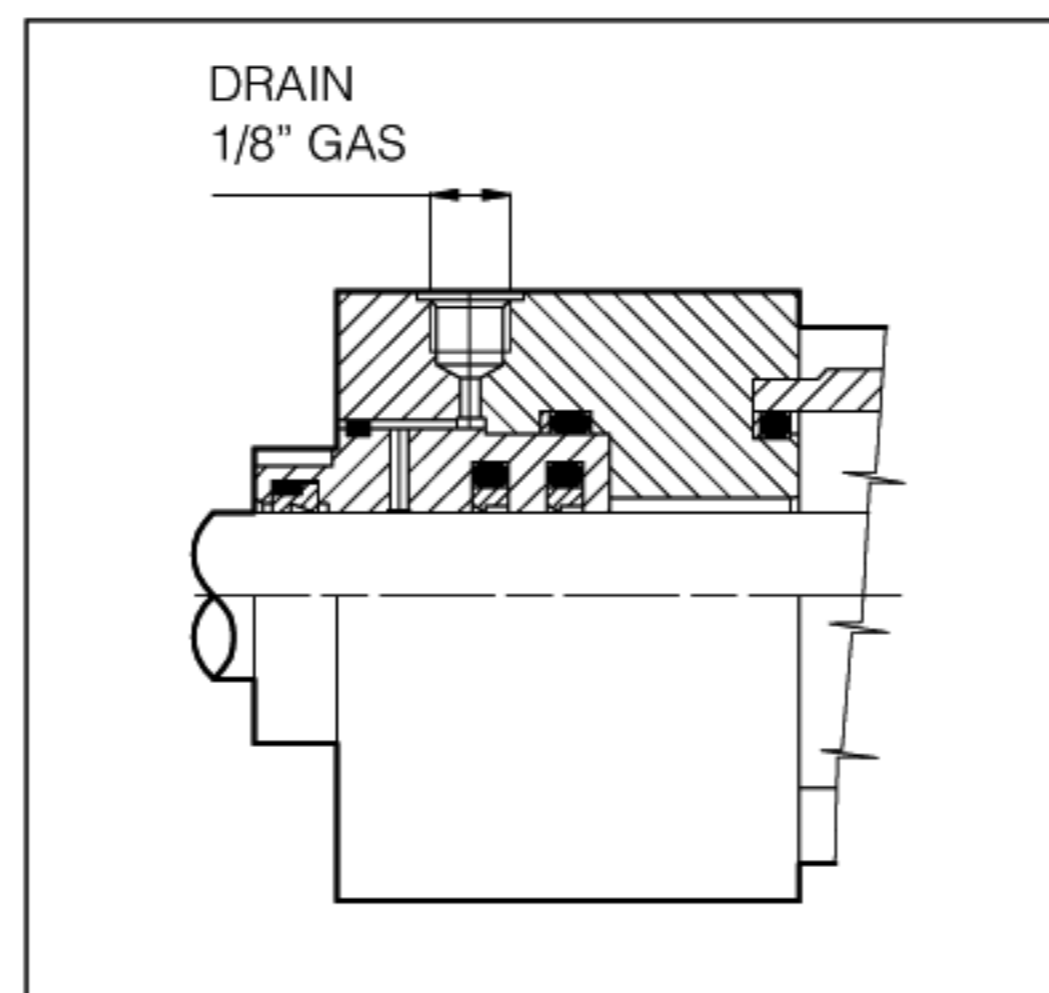
the environment: proper air filters on the power unit tank to be always provided;
 - filter the fluid when filling the tank (new fluid is contaminated) with filtration Group GL-15 (table L150) or similar.

1.5 Hydraulic drains and return lines

The function of drains is essential in all systems, because they define the minimum pressure level.

They must be connected to the tank without counter-pressures.

Drain connections is provided on tie rod side of the servocylinder, see figure.



Return line from proportional valve to tank has to be sized in order to avoid variable counter pressure $< 1 \text{ bar}$; for this reason it is recommended to use multiple separated return lines directly connected to tank.

1.6 Fluid conditioning

A high-performance system must be thermaly conditioned to ensure a limited fluid temperature range (generically between 40 and 50°C) so that the fluid viscosity remains constant during operation.

The operating cycle should start after the prescribed temperature has been reached.

1.7 Air bleeds

Air in the hydraulic circuits affects hydraulic stiffness and it is a cause of malfunctioning. Air bleeds are provided in the proportional valves and servocylinders; air dump valves must be inserted at possible air accumulation points of the hydraulic system.

Following additional warnings to be considered:

on starting the system all the bleeds must be released to allow removal of air. In particular for servocylinders be careful to bleed the transducer chamber, which is done by releasing the dump valve at the rod end;

3 INTEGRAL ELECT. WIRING SECTION

- 3.1 Standard version
- 3.2 Option /I
- 3.3 Option /Q
- 3.4 Option /F
- 3.5 Option /S and /Z
- 3.6 Option /Z for digital drivers
- 3.7 Option /SP and /ZP for digital drivers

4 COMMAND SIGNALS WIRING

5 SHIELD CONNECTIONS

- for the piping untight the connections;
- the system must be bled on first start-up or after maintenance;
- use a precharged check valve (e.g. to 4 bars) on the oil general return line to tank to avoid emptying of the pipes following a long out of service.

2 ELECTRONIC SECTION

2.1 Power supply

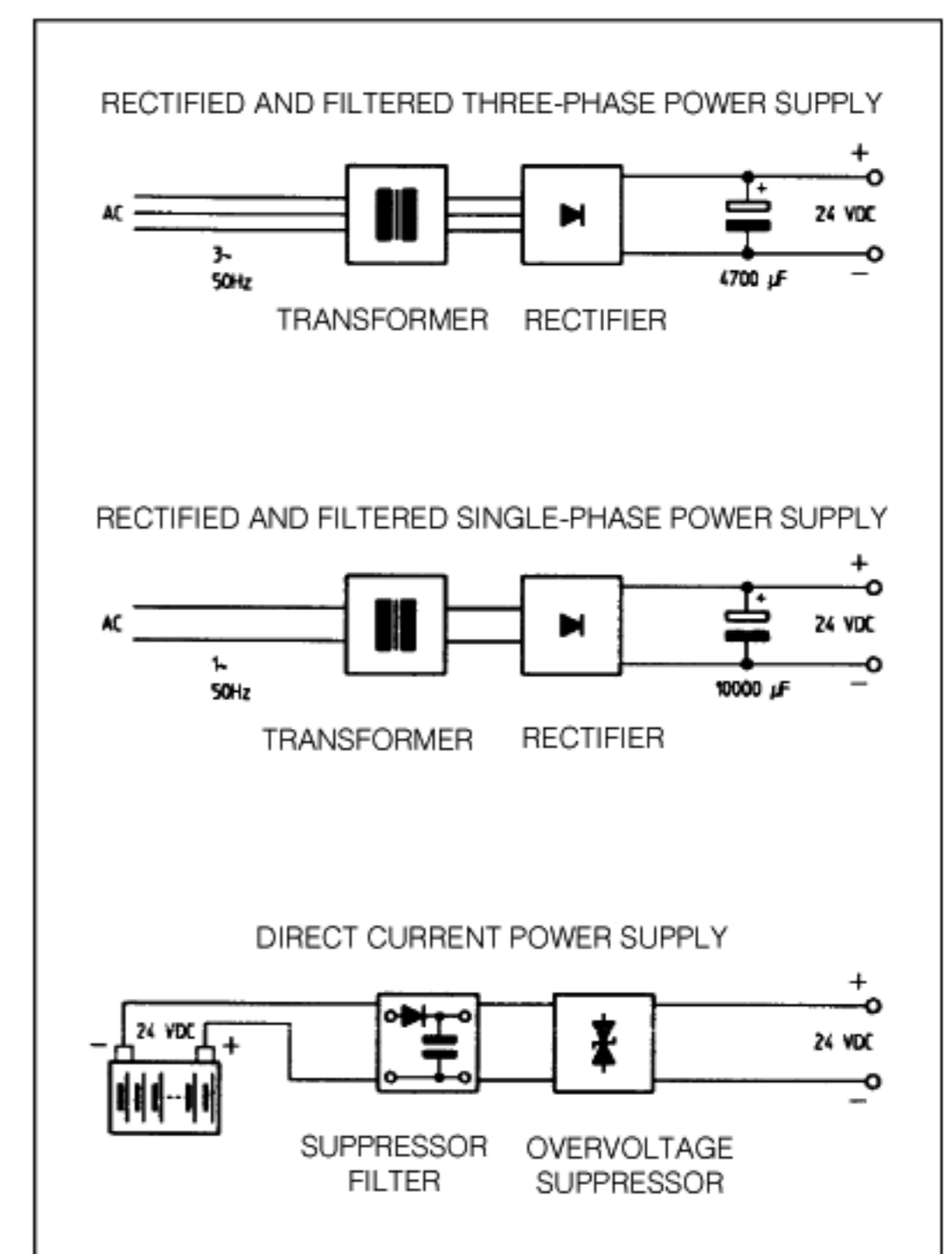
The voltage values to be within the following range (depending on the type of supply devices):

nominal voltage: $V = 24 \text{ V}_{\text{DC}}$;
 filtered and rectified voltage: $V_{\text{rms}}=21 \div 33 \text{ V}$ (ripple max = $2V_{\text{pp}}$);

The supply device must be sized in order to generate the correct voltage when all utilities require max current at same time; in general 50W max intake electrical power can be considered for each supplied valve.

Following additional notes to be considered, see figure below:

- power supply from a battery: overvoltages (typically greater than 34 Volts) damage the electronic circuits; it is recommended the use of suitable filters and voltage suppressors;
- rectified AC power supply: the average value to be within the limit $V_{\text{rms}} = 21 \div 28 \text{ Volts}$, with a supply capacitor equal to $10000 \mu\text{F}$ for each 3A of current expected when single-phase power supply; $4700 \mu\text{F}$ when three-phase power supply.



2.2 Electrical wiring

The power cables (coils, electronic adjusters or other loads) to be separated from the control cables (references and feed-backs, signal grounds) to avoid interferences.

The electrical cables of the electronic signals must be shielded as indicated in section 5 with shield or cablebraid connected to the ground (according to CEI 11-17).

Recommended cable cross section;

- Supply and earth: 0,75 mm²;
- Coils: 1mm² (Lmax = 20 m); 1,5 mm² (for longer distance) of shielded type;
- Voltage reference and LVDT feedback: 0,25mm² (Lmax = 20m) of shielded type;

Note: current reference signals options must be provided when greater lengths apply to reference and feedback connections; suitable electronic units and transducers or voltage to current converters are available.

- Service signal: 0,25mm² (Lmax = 20 m) of shielded type;
- Electronic transducers: 0,25mm² (Lmax = 20 m) of shielded type;

2.3 Suppression of interferences by electrical noise

When starting the system, it is always advisable to check that feedbacks, references and signal grounds are free from interferences and electrical noise which can affect the characteristics of the signals and generate instability in the whole system.

Electrical noises are high non-stationary oscillations both on amplitude and frequency around the signal average value; they can be suppressed by shielding and grounding the signal cables, see section 5.

Most of electrical noises are due to external magnetic fields generated by transformers, electric motors, switchboards, etc.

2.4 Integral drivers service signals and options

- Monitor signal (standard)

The output signal (0÷5V, ±10V) is available to monitor the current to the solenoid (AE, AES) or the spool position of the valve (TE, LE, TES, TERS). Both signals can be connected to main control unit for sequence operations and diagnostics.

Note: electrical monitor signals taken via valve electronics must not be used to switch off the machine safety functions. This is in accordance with the European regulations standard (Safety requirements fluid Technology systems and components);

- Current reference signal (option /I)

It provides the 4÷20 mA current reference signal and the current feedback signals instead of the standard 0÷10V (± 10V). It is normally used in case of long distance between the machine control unit and the valve or where the reference signal can be affected by electrical noise. In case of breakage of the reference signal cable, the valve functioning is disabled.

- Fault signal (option /F)

Safety option providing an output signal which switches to zero in case of interruption of the transducer feedback cable. In this condition the valve functioning is disabled.

- Enabling contact (option /Q)

Safety option providing the possibility to enable or disable the valve functioning without cutting the power supply.

- Fail safe conditions

In case of no feedback signal due to shortcircuit or break in the transducer cabling, an automatic inhibition of the control card operates and zero current is fed to valves. At the same time a LED (inside the housing for the integral electronics) is signalling the emergency condition.

- Logic state signals for E-RI-TE and E-RI-LE (option /S)

This function gives three output signal in order to control in real time the valve's spool position to allow the diagnostic controls. The signal "Zero position" is "on"

(22V 20 mA) when the spool is in the central position, while the other two signals ("Position S1" and "Position S2") are "on" when the spool is moving according to the excitation of the S1 or S2 solenoid, respectively. This safety signals can be used to switch-off the machine safety functions.

- Enable fault and monitor for E-RI-TE and E-RI-LE (option /Z)

Option providing the same characteristics of /F and /Q plus the monitor signal 0 ÷ 10 V (or ± 10 V) of the spool position.

- Double power supply enable and fault for E-RI-TE, E-RI-TERS, E-RI-LES (option /Z)

Safety option, specifically introduced for -BC and -BP fieldbus interfaces, provides two separated power supplies for the digital electronic circuits and for the solenoid power supply stage. The Enable and Fault signals are also available. The option /Z allows to interrupt the valve functioning by cutting the solenoid power supply (e.g. for emergency, as provided by the European Norms EN954-1 for components with safety class 2), but keeping energized the digital electronic circuits, thus avoiding fault conditions of the machine fieldbus controller.

- P/Q control for E-RI-TE-PS and E-RI-LES-PS (option /SP)

Option providing in addition to the standard valve functions, a closed loop control of the max pressure regulated by the proportional valve in the system, thus realizing a P/Q regulation. A remote pressure transducer must be installed on the system and its feedback has to be interfaced to the valve. If the real value of the pressure in the system remains below the relevant reference signal, the driver regulates in closed loop the valve's spool position, according to the flow reference signal. When the real pressure become close to the relevant reference signal, the driver automatically performs the closed loop control of the pressure. This option permits to realize accurate dynamic pressure profiles. Up to 4 set of PID pressure parameters can be real time selected during the axis motion via on-off signals to the main 12 poles connector to optimize the control performances in the different phases of the machine cycle.

- P/Q control for E-RI-TE-BC (-BP) and E-RI-LES-BC (-BP) (option /ZP)

Integral digital P/Q controller providing the same characteristics of option /SP plus additional double power supply, enable and fault. In this option the multiple set of PID pressure parameters can be real time selected during the axis motion through the -BC or -BP interfaces.

- Current feedback signal for E-RI-PES (option /C)

The pump electronics is set to receive 4÷20 mA feedback signal from the remote pressure transducer, instead of the standard 0÷10 V.

- P/Q control for E-RI-PES-PS (option /S)

Option providing up to 4 set of PID pressure parameters can be real time selected during the axis motion via on-off signals to the 12 poles connector to optimize the control performances in the different phases of the machine cycle.

- P/Q control for E-RI-PES-BC (-BP) (option /Z)

Integral digital P/Q controller providing the same characteristics of option /SP plus additional double power supply, enable and fault. In this option the multiple set of PID pressure parameters can be real time selected during the axis motion through the -BC or -BP interfaces.

2.5 Electronic calibrations

The valves with integral electronics normally don't need any calibration by final customer because these operations have been already performed before delivery of component (the

valves with integral electronics are used more and more for their easier servicing and improved reliability).

However Bias adjustment is allowed, to permit the regulation between the input reference electrical zero and the spool center position (actuator in a steady position); a new calibration can be executed with particular hydraulic conditions (i.e. cylinder with high differential ratio value and/or high Δp pressure operations). When electronic regulators in Eurocard or other format are installed in the control unit, the setting procedures are shown on related technical tables; consult them carefully before proceeding with the start-up. Personalised calibrations in case of particular requirements can be carried out with the collaboration of Atos technical dept.

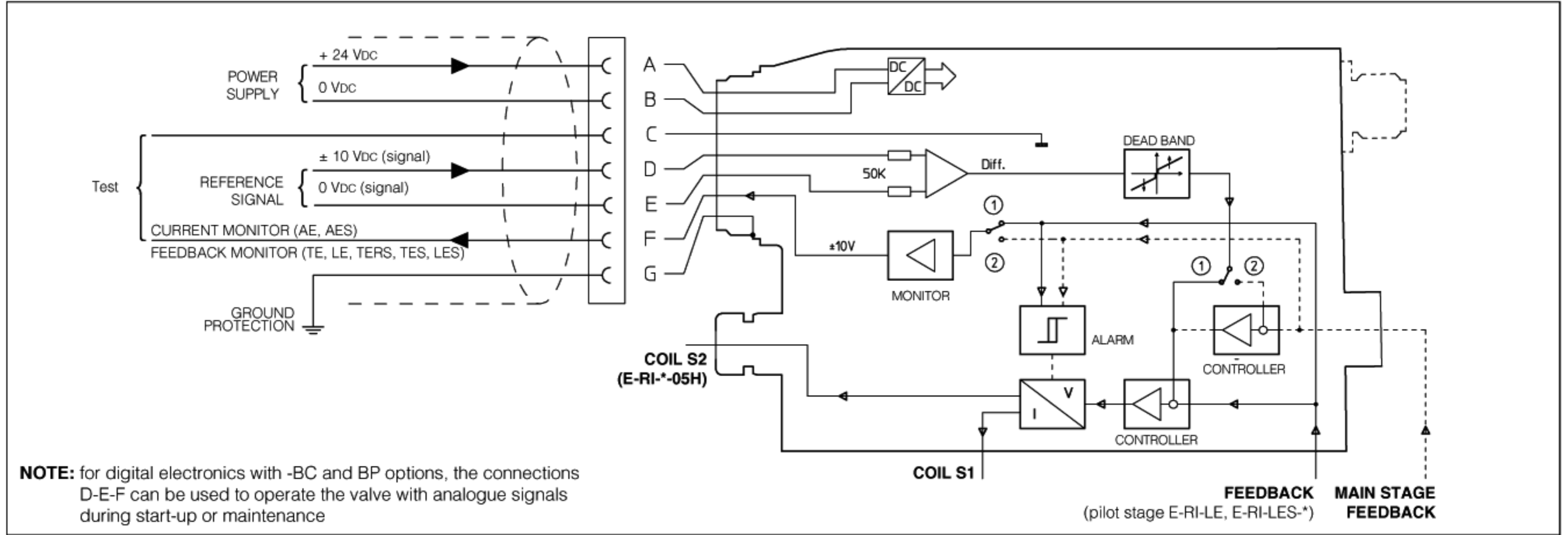
2.6 Temperatures and environments

Always check that the operating environment is compatible with the data given in the product tables. If necessary provide conditioning of the electronic cabinet.

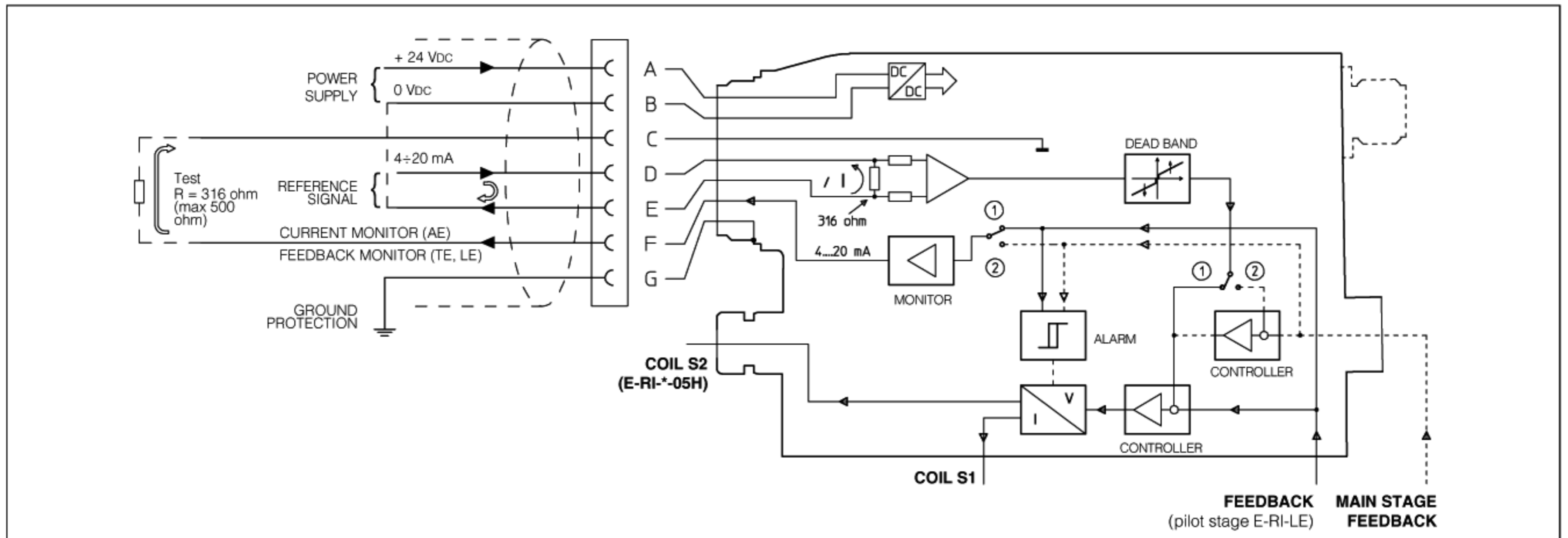
In particular the integral electronics cannot be used when ambient temperature is higher than +60°C or lower than -20°C (-20°C to +50 °C for digital -TERS execution).

3 ELECTRONICS WIRING

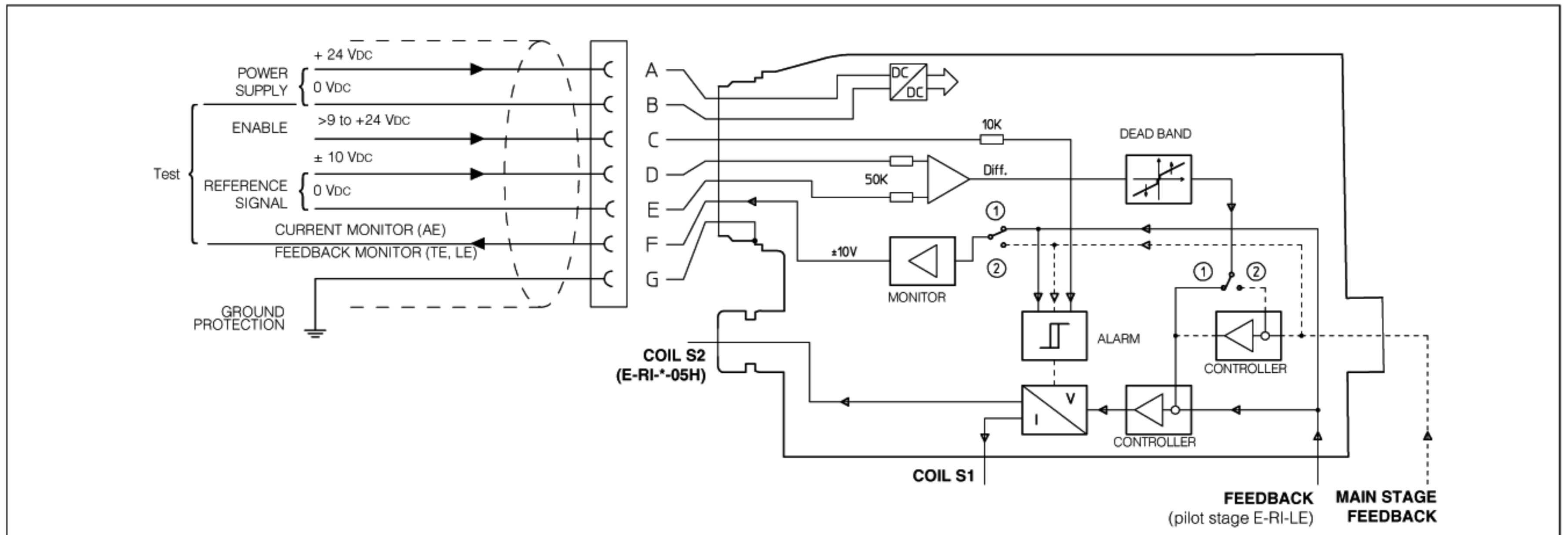
3.1 E-RI-AE (-AES), E-RI-TE (-TES), E-RI-LE (-LES), E-RI-TERS Standard versions



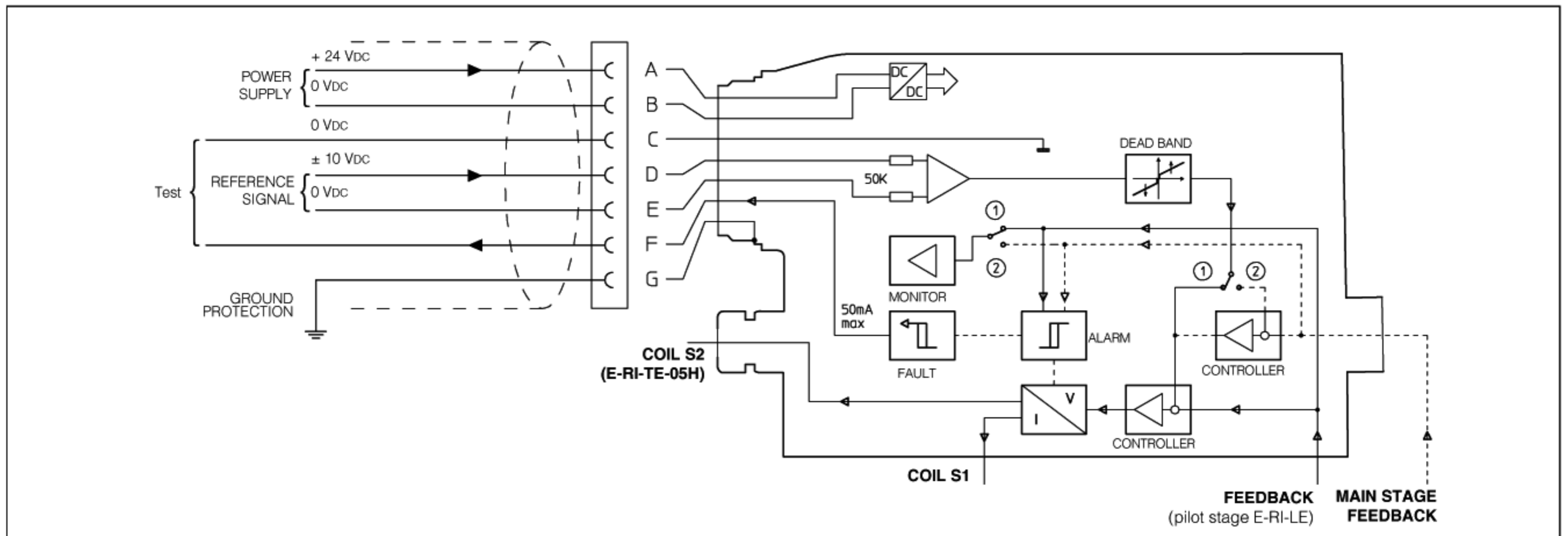
3.2 E-RI-AE, E-RI-TE, E-RI-LE, E-RI-TERS Option /I



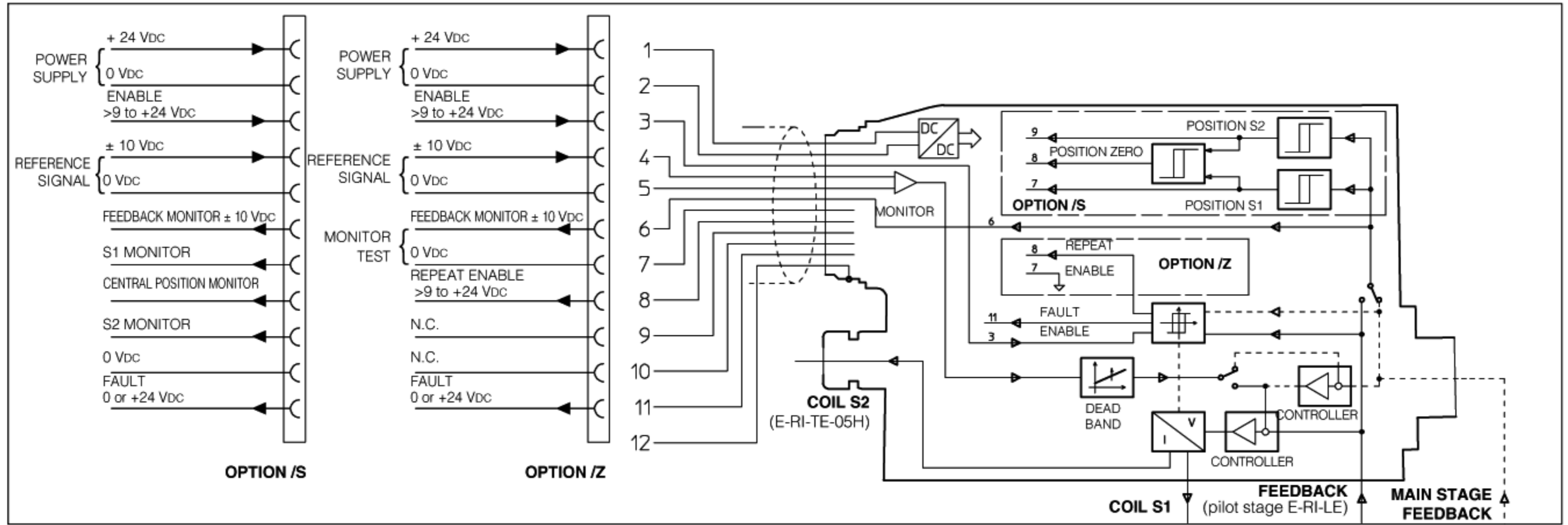
3.3 E-RI-AE, E-RI-TE, E-RI-LE Option /Q



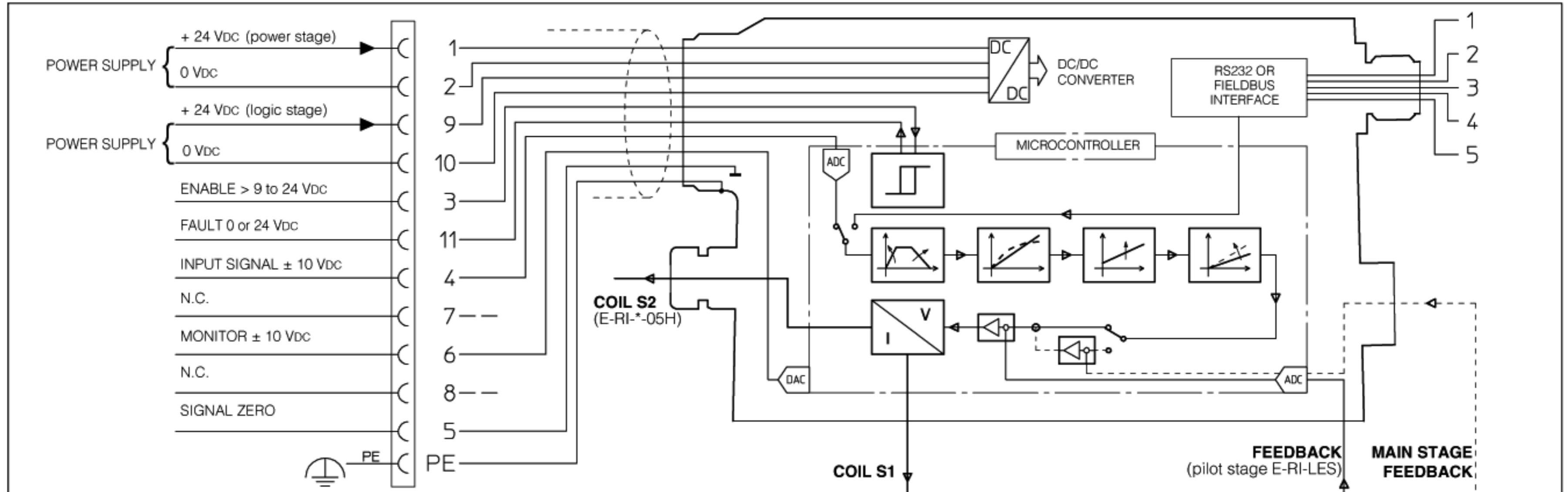
3.4 E-RI-TE, E-RI-LE Option /F



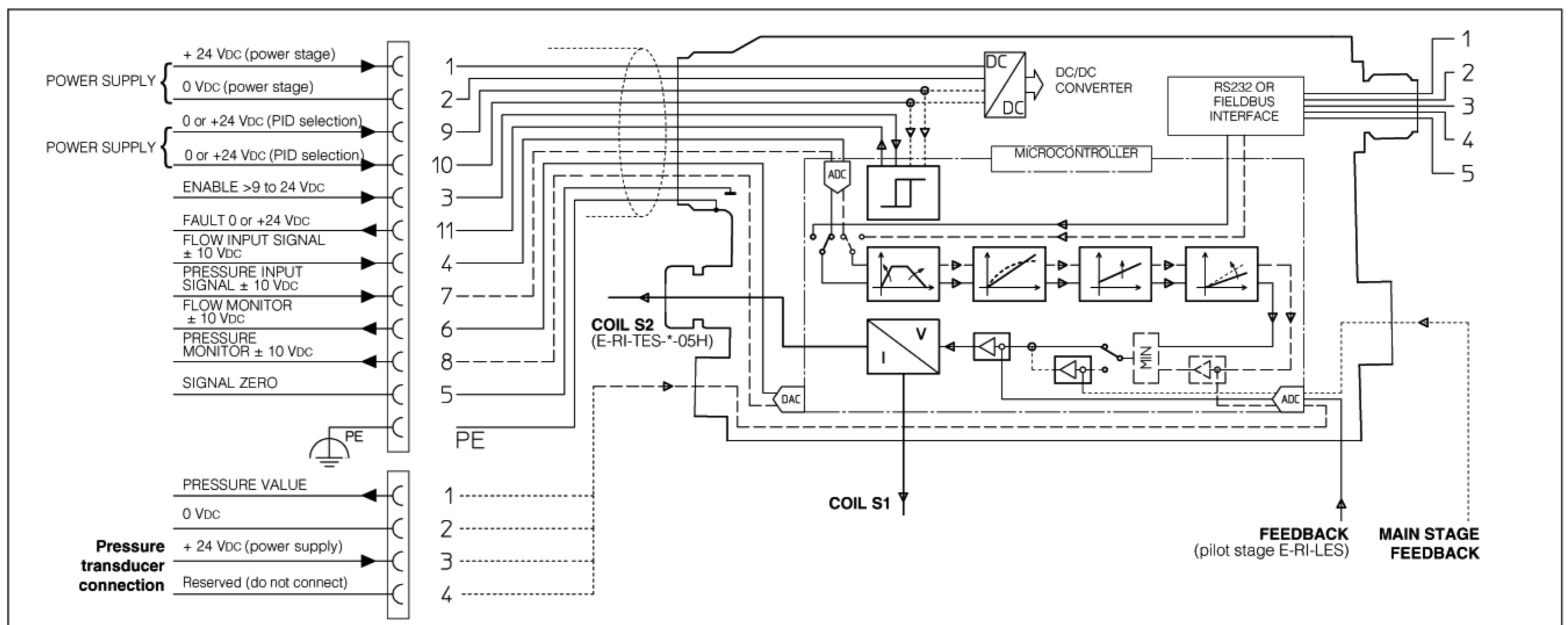
3.5 E-RI-TE, E-RI-LE Option /S and /Z (12 pin connector)



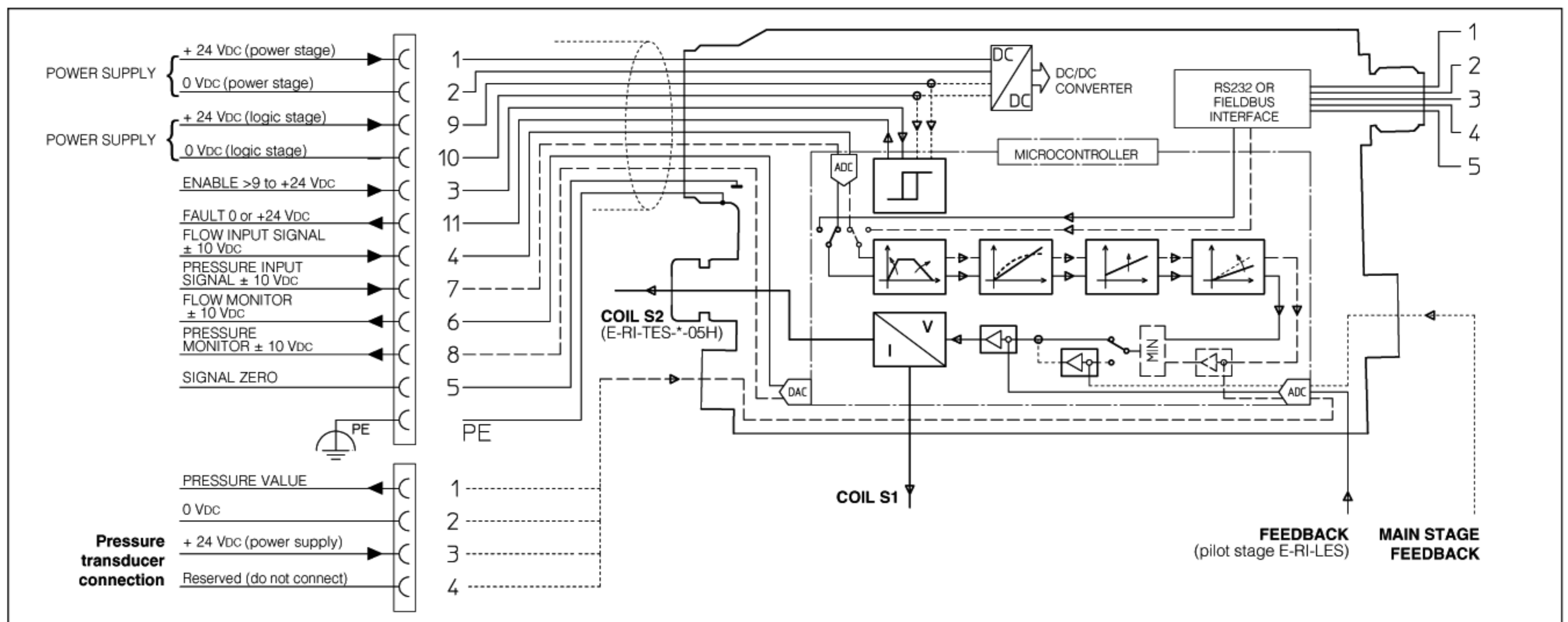
3.6 E-RI-AES, E-RI-TES, E-RI-LES Option /Z (12 pin connector)



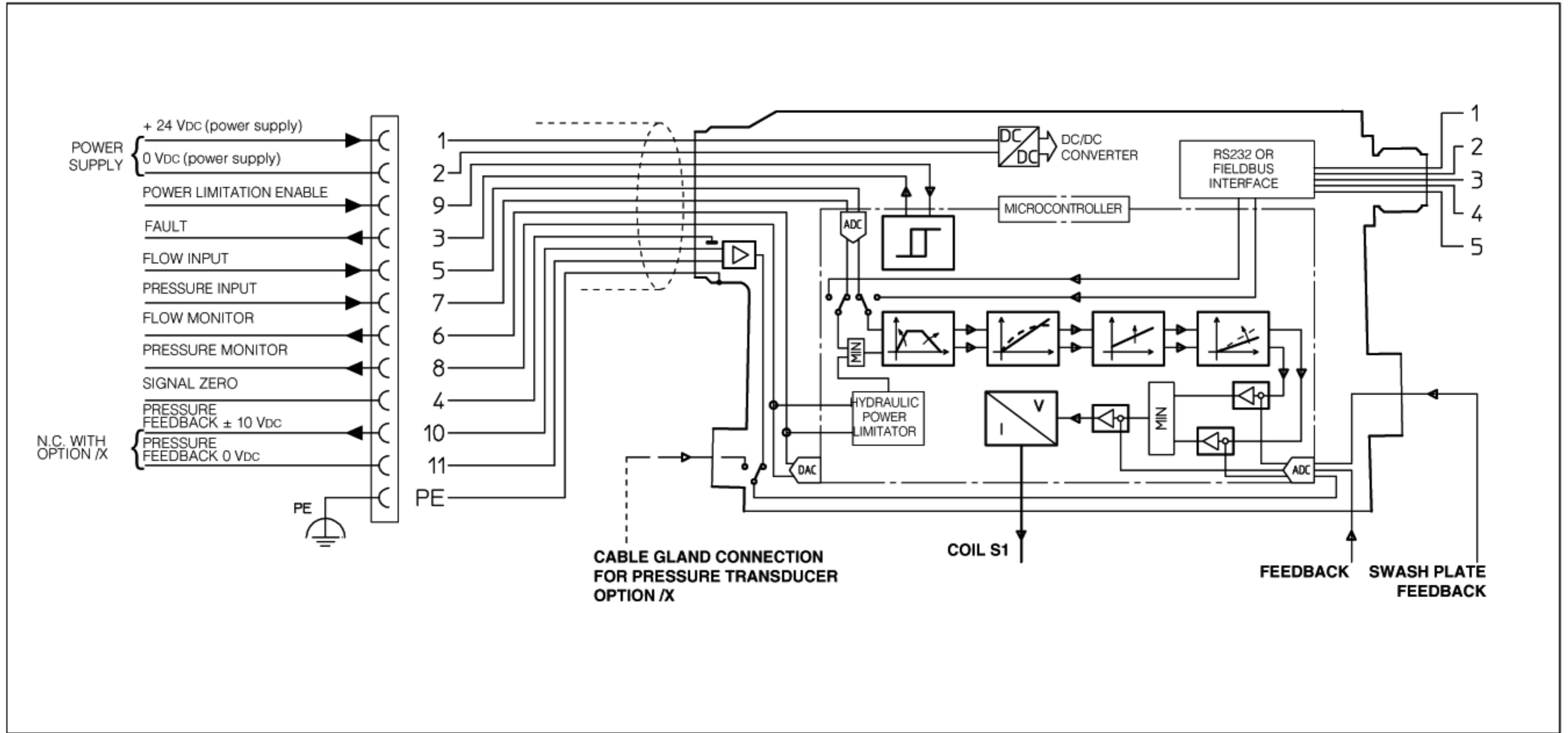
3.7 E-RI-TES, E-RI-LES Option /SP (12 pin connector)



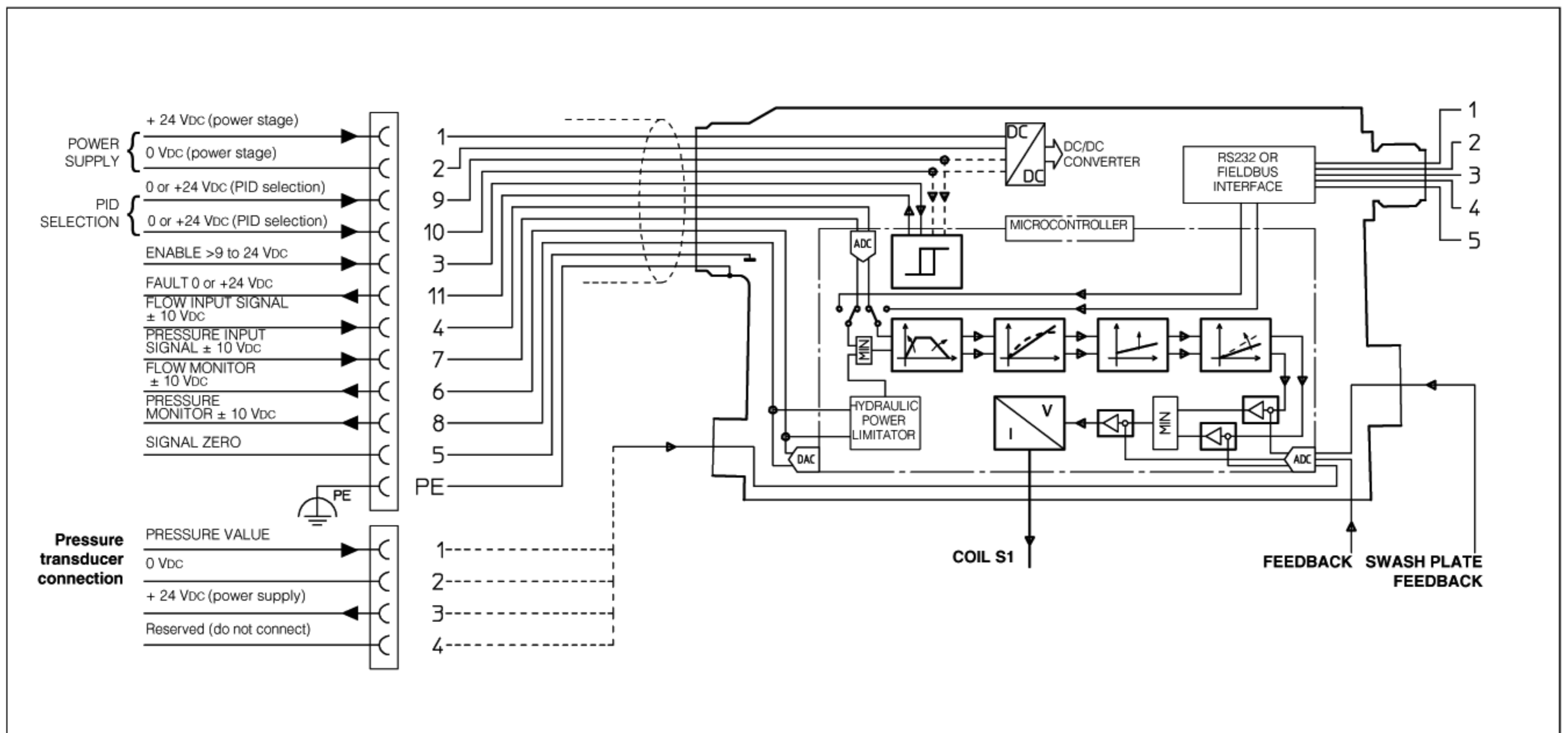
3.8 E-RI-TES, E-RI-LES Option /ZP (12 pin connector)



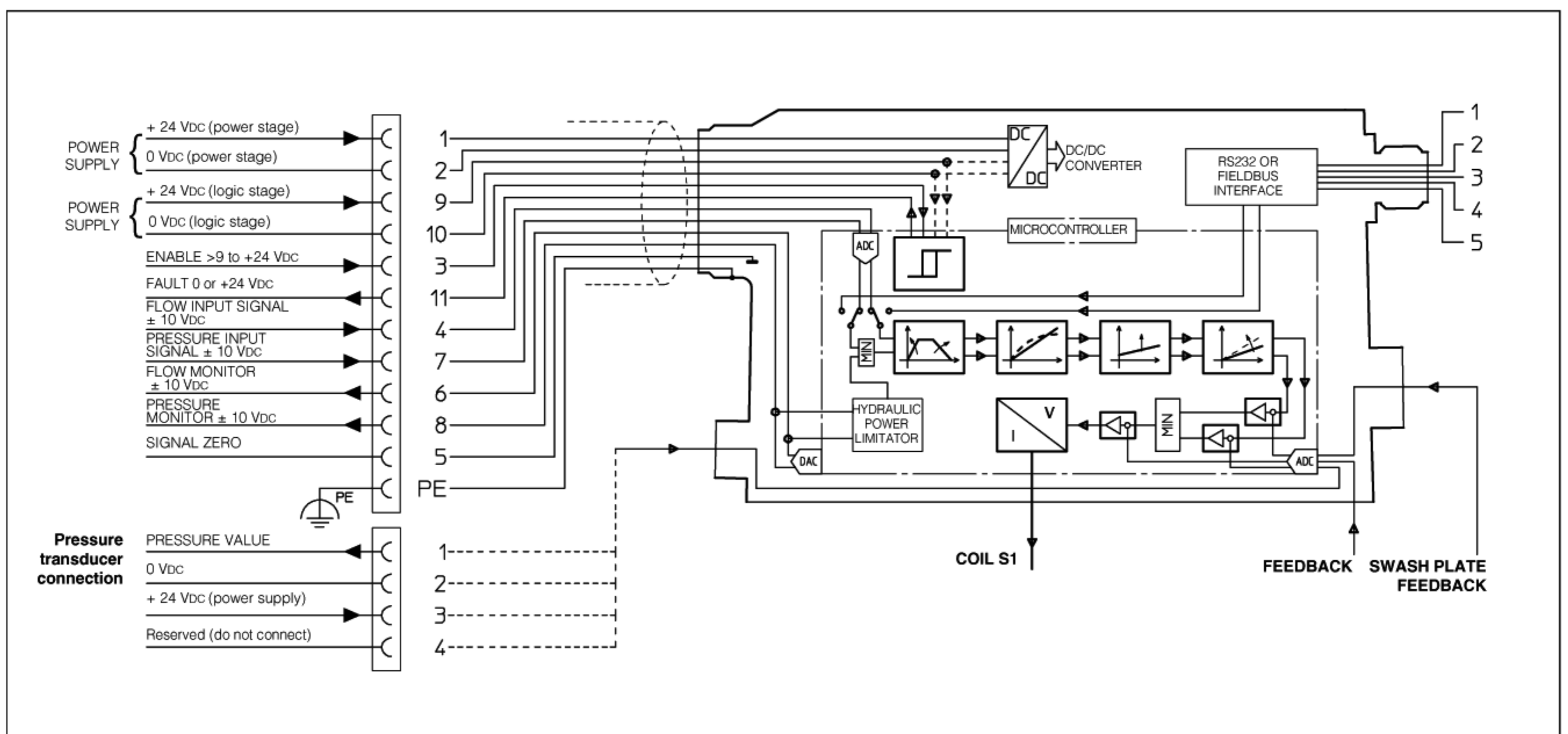
3.9 E-RI-PES Standard and option /X



3.10 E-RI-PES Option /S



3.11 E-RI-PES Option /Z



4 COMMAND SIGNAL WIRING

The connection of the command signal to the electronics is depending to the type of signal generated from the PLC or CNC. The following figures show the typical connections in case of common zero or differential command situations.

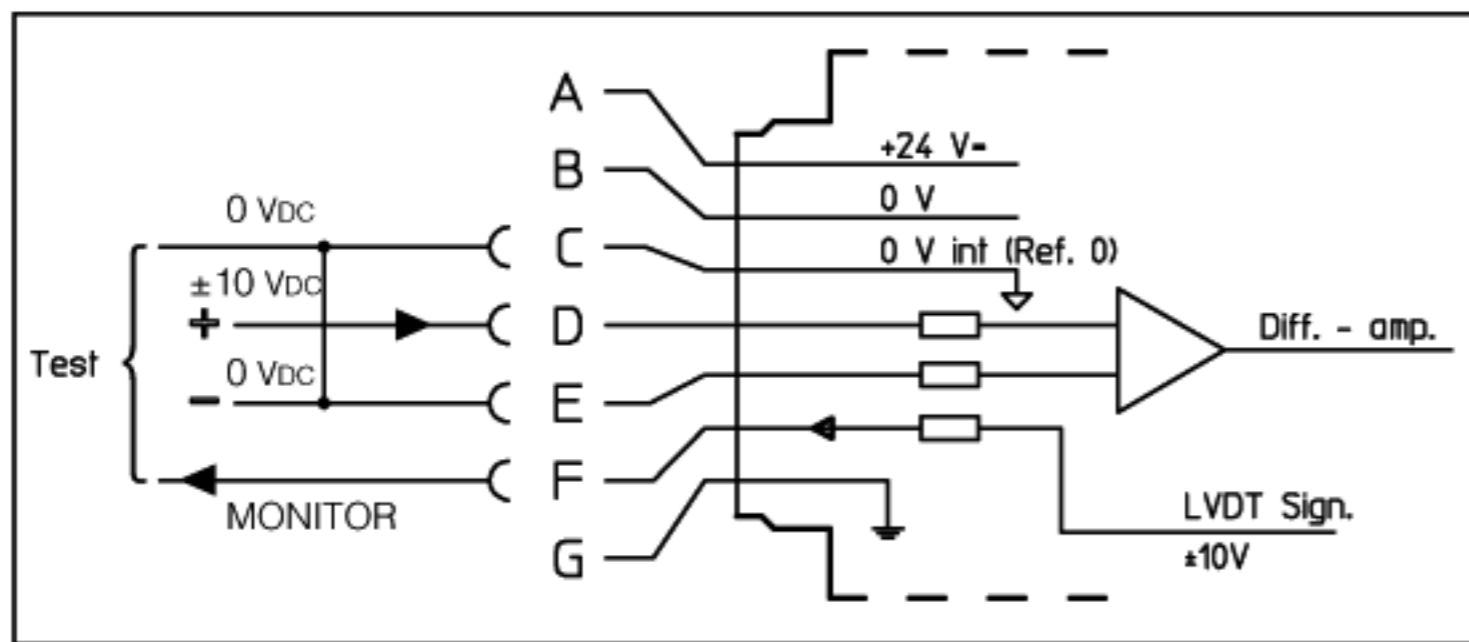


Fig. A Power supply and signal common zero

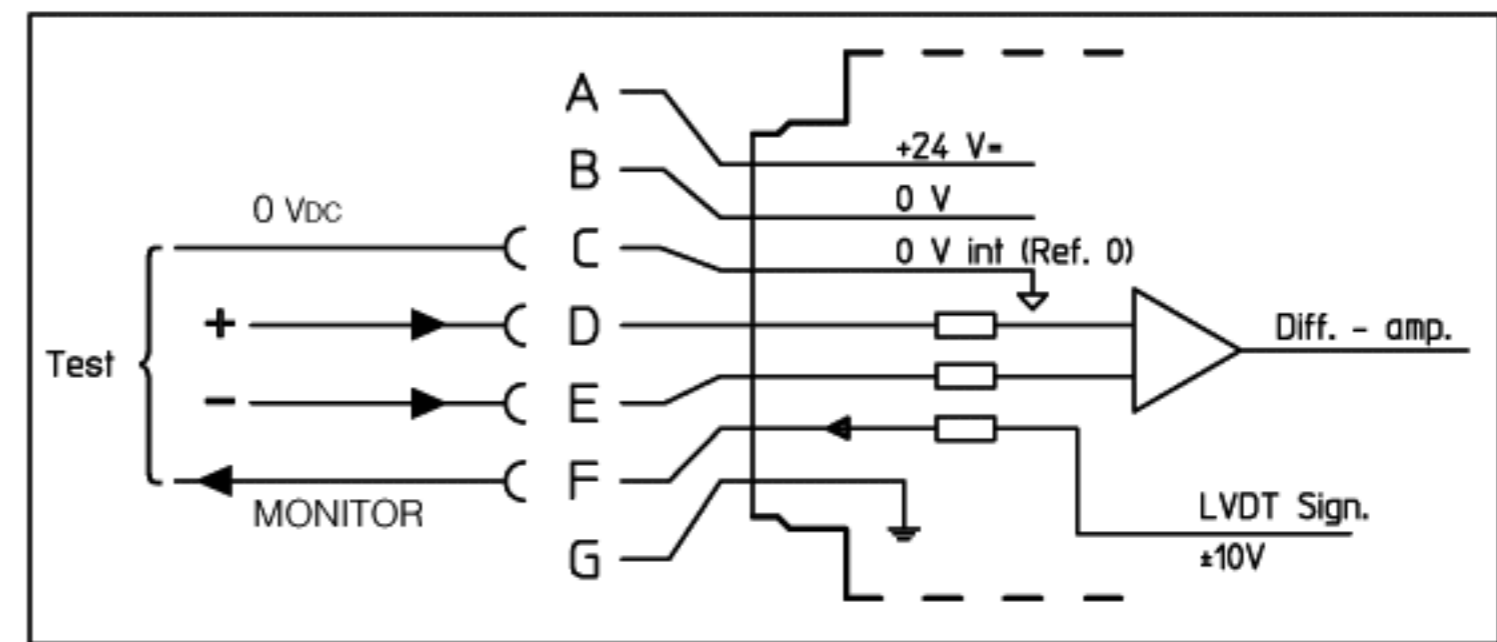


Fig. B Differential signals not connected with zero (floating)

COMMAND SIGNAL FOR OPTION /I

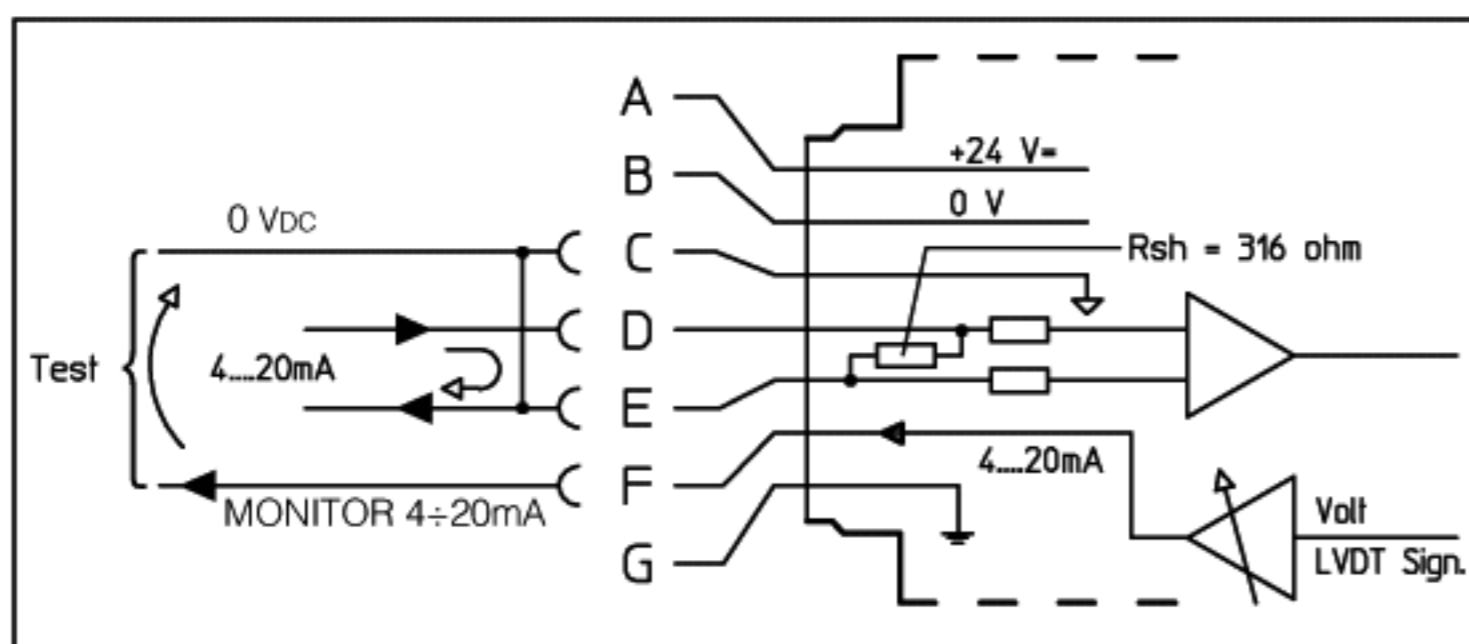


Fig. C Common zero

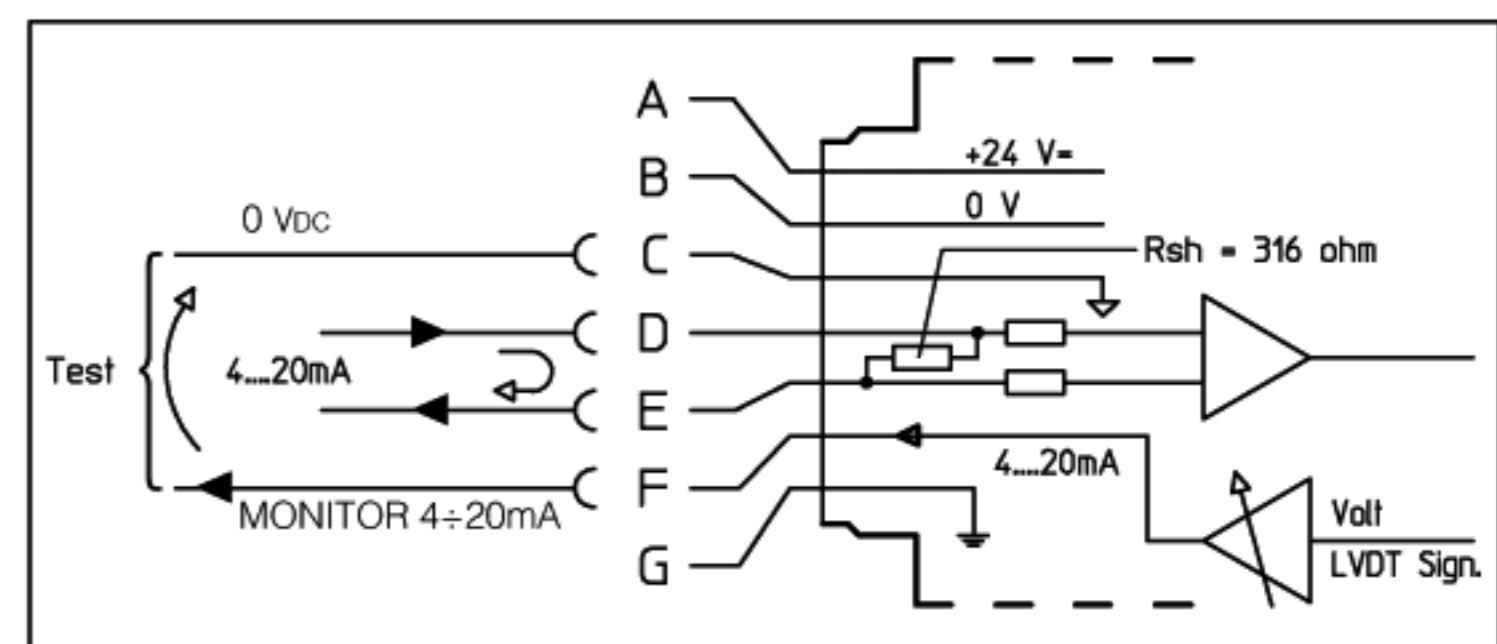


Fig. D Differential input signals

5 SHIELD CONNECTIONS

The correct shielding of signal cables has to be provided to protect the electronics from electrical noise disturbances, which could affect the valve functioning. Examples of correct shielding criteria are shown in the following fig. E and F. The shield connections of fig. G and H must be avoided because they could generate ground loops which enhance the noise effect.

CORRECT SHIELD CONNECTIONS

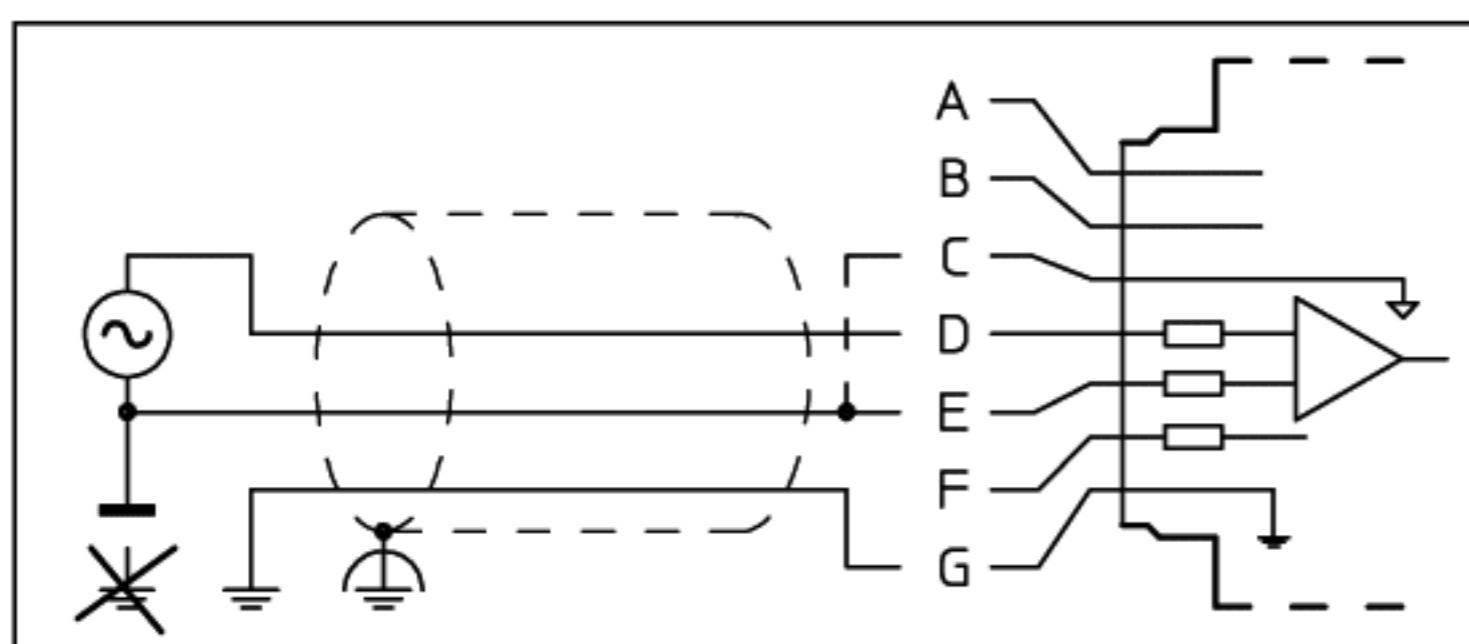


Fig. E Shield connected to the protected earth

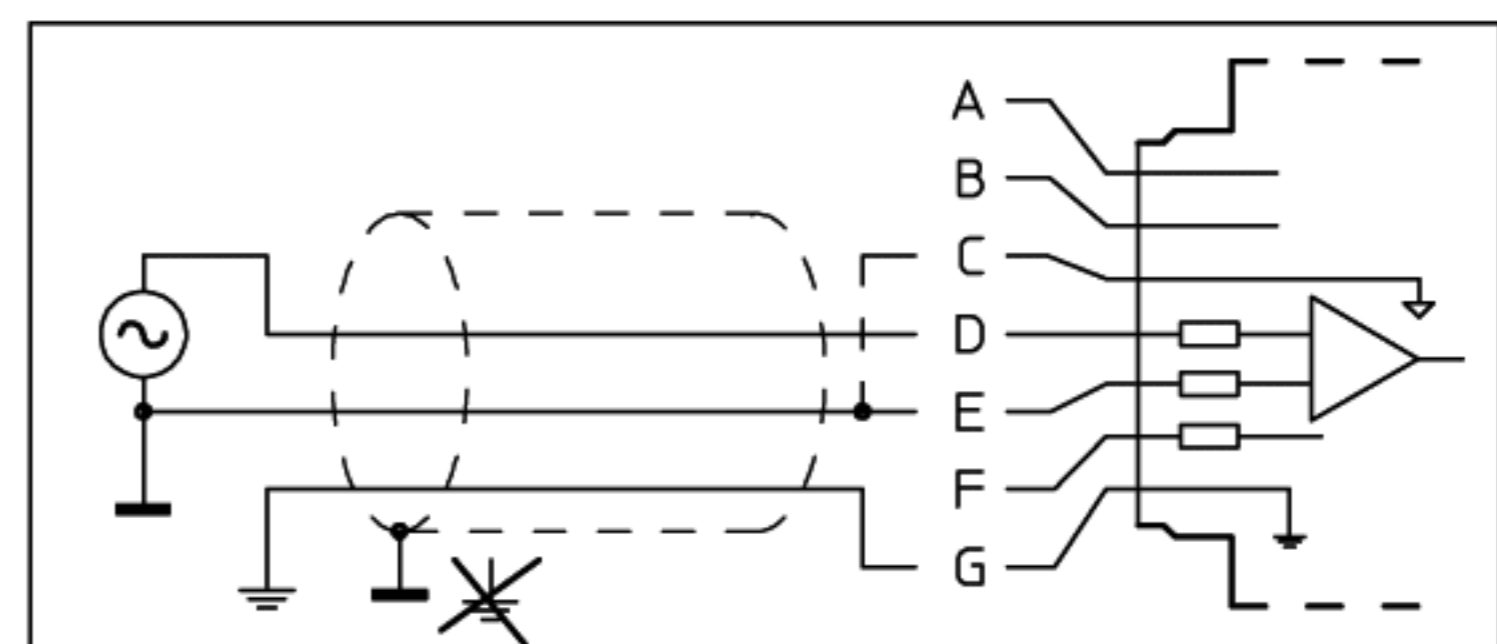


Fig. F Shield connected to the same power supply GND

WRONG SHIELD CONNECTIONS

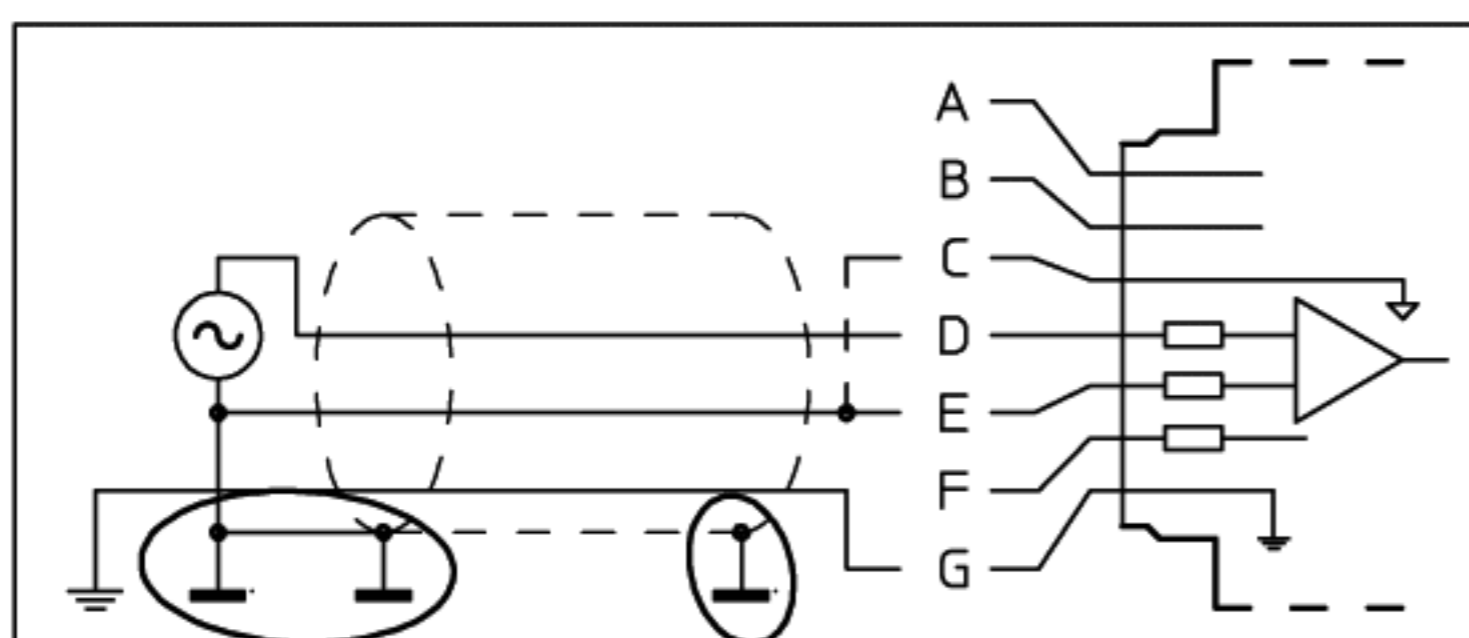


Fig. G Never connect the shield on both sides

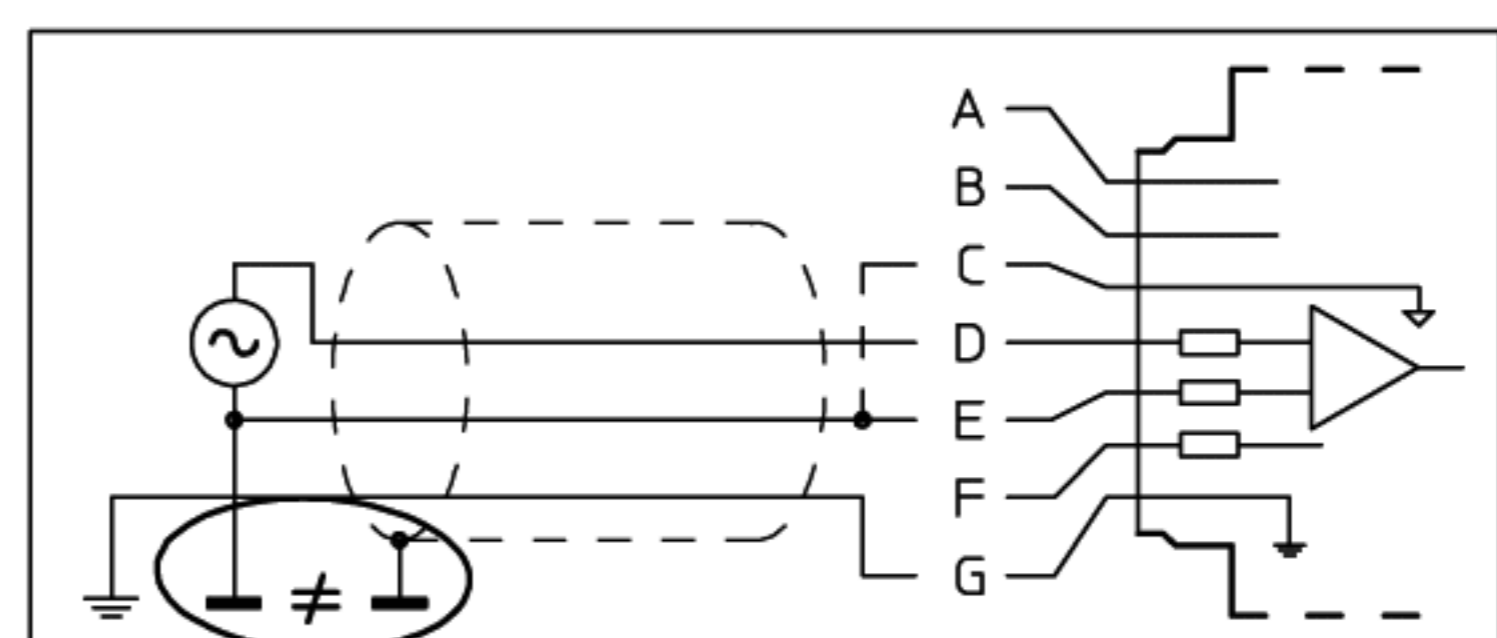


Fig. H Never connect the shield to grounding facilities having different potential

Symbols: Standard earth Supply GND Protected earth

6 TROUBLE SHOOTING TABLES

To evaluate the fault and to find the defective component within an electrohydraulic system it is necessary a good cooperation between electronic and hydraulic engineers.

Besides a good knowledge of the technical tables for each component, for performing analysis of the system it is necessary to evaluate the hydraulic scheme and the electric wiring diagram related to operation cycle.

There is no general recipe for succes in fault finding due to quite diverse nature of the electrohydraulic systems; however the following table provides a useful start point.

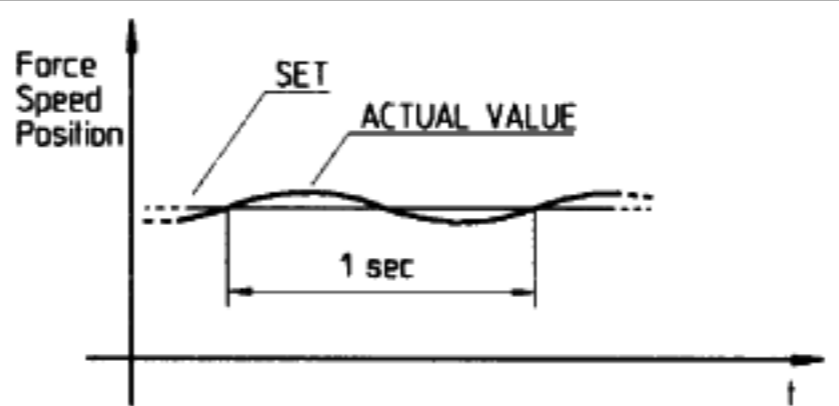
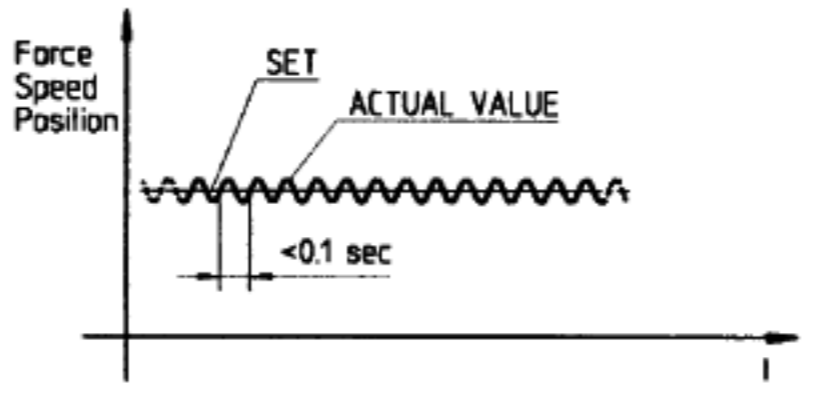
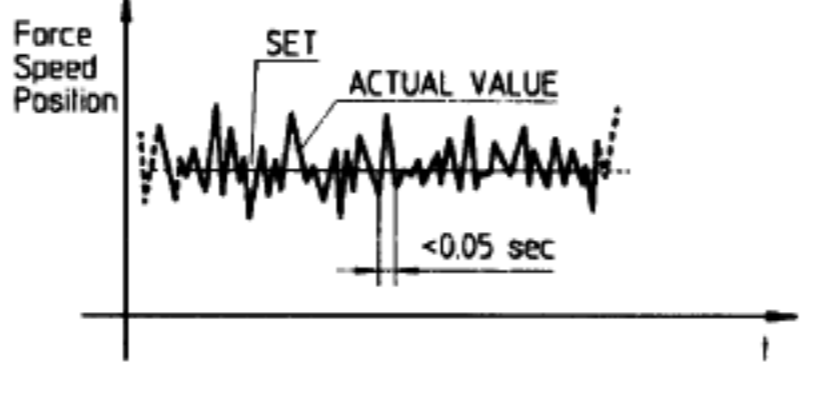
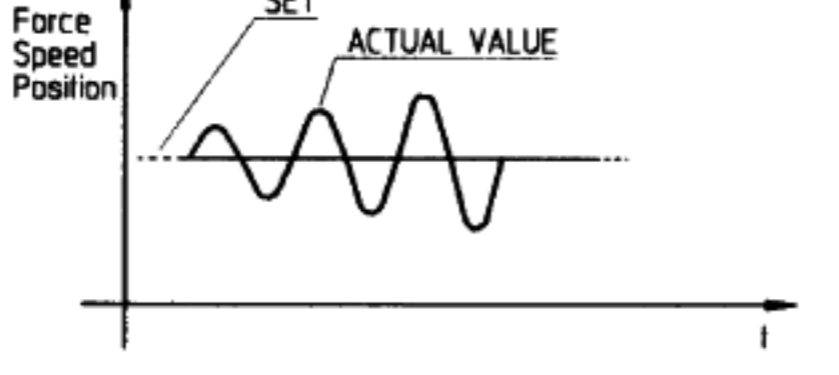
Notes:

- Most problems are solved by the replacement of defective components on site. The defective components can be repaired by the manufacturer.
- Following tables don't consider a system design fault

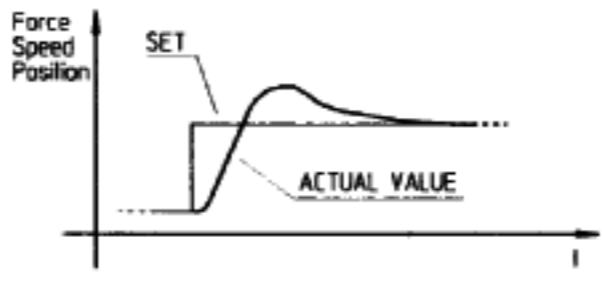
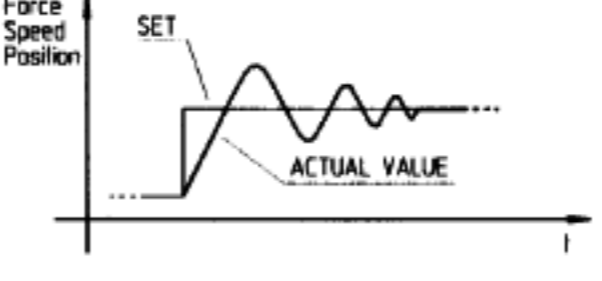
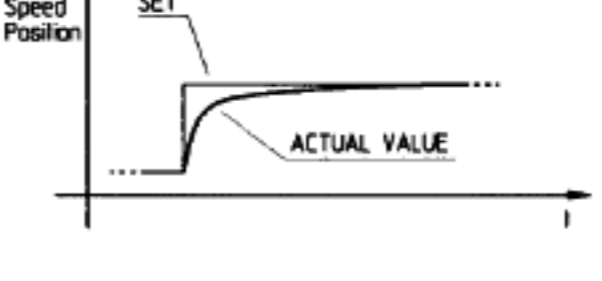
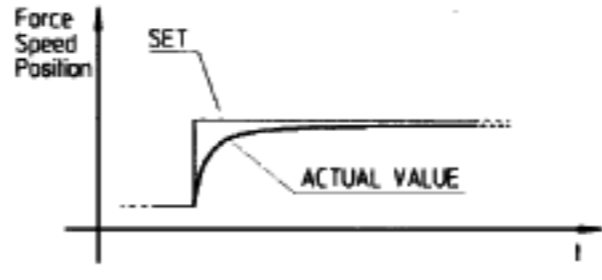
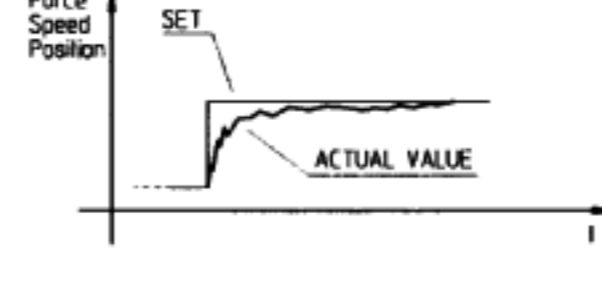
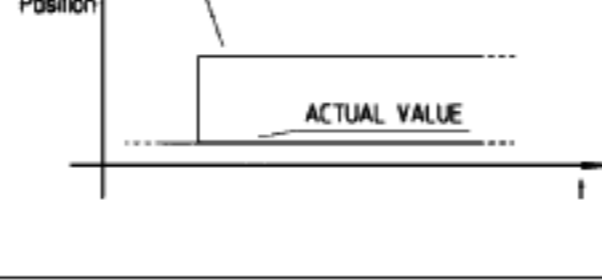

6.1 Open loop applications

PROBLEMS	CAUSES OF THE FAULTS	
	Mechanical/Hydraulic	Electrical /Electronic
Unstable axes movement Pressure and/or flow fluctuations	Defective pump Air in the circuit Fluid contaminated Insufficient piloting pressure of double stage valves Stick-slip effect due to excessive friction of cylinder seals Speed below minimum for hydraulic motors	Insufficient powered electrical supply Noisy signals-bad grounding or shielding Electrical or electromagnetic disturbances
Actuator overrun	Hoses too elastic Remote controlled check valve not closing immediately Insufficient bleeding Internal leakages	Bias current set too high Ramp time too long Limit switch overrun Electrical switching time too slow
Standstill or not controllable axes	Defective pump Proportional control valve blocked (dirt) Hand valves and settings not in correct position	Cabling error Open circuit in electrical control leads Signalling devices incorrectly set or defectives Lack of electrical power and/or reference signal Transducers mechanically uncalibrated
Actuator running too slow	Internal pump leaks due to wear Flow control valve set too low	Reference signal not correct Scale adjustment not correct
Insufficient output forces and torques	Excessive resistance in the return and delivery lines Operating pressure setting of control valves too low Excessive pressure drop across control valves Internal leaks of pump and valves due to wear	Reference signal not correct Scale adjustment not correct
Line hammer during control operation	Switching time of proportional control valves too rapid Throttles or orifices damaged No throttling before accumulator system Excessive masses and forces applied to drive	Ramp time too short or absent
Excessive operating temperature	Insufficient lines cross section Excessive continuous delivery Pressure setting too high Cooling system not operative Zero pressure circulation inoperative during working intervals	
Excessive noise	Filters blocked Foaming of the fluid Pump or motor mounting loose Excessive resistance in the suction line Proportional control valves buzz Air in the valve solenoid	Dither adjustment not correct

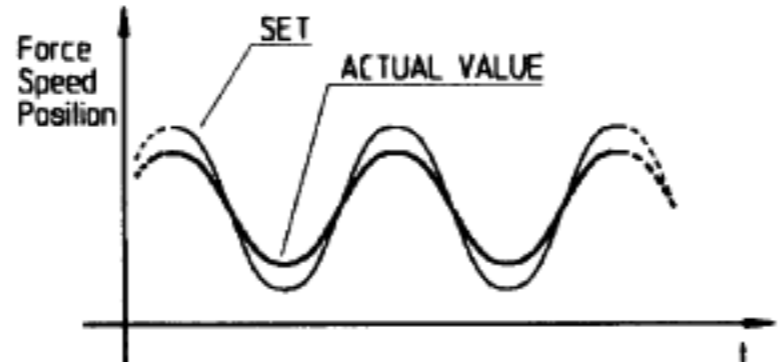
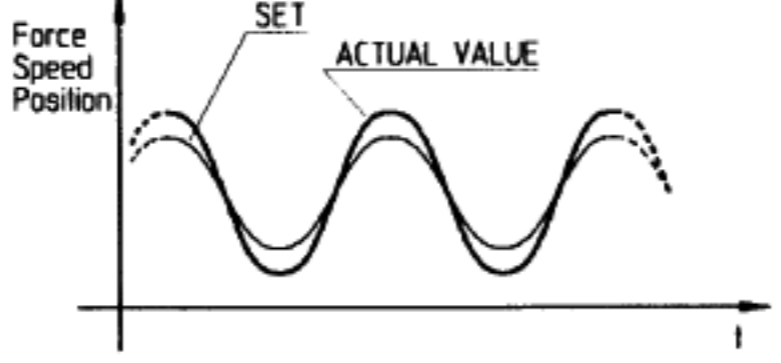
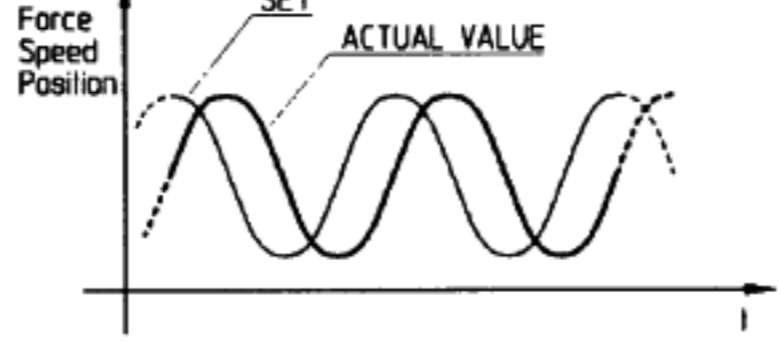
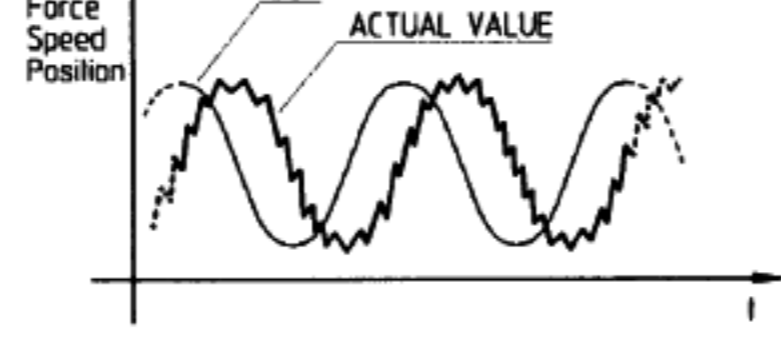
6.2 Closed loop applications - static conditions

PROBLEMS	CAUSES OF THE FAULTS	
	Mechanical/Hydraulic	Electrical /Electronic
Low frequency oscillations 	Insufficient hydraulic power supply Insufficient piloting pressure Proportional valve defective due to wear or dirt	Axes card proportional and integral Gains set too low Axes card Sampling time too long
High frequency vibration 	Foaming of the fluid Prop. valve defective due to wear or dirt Too high Δ pressure across valve Air in the solenoid of the proportional valve	Axes card proportional Gain set too high Electrical noises
Short time peak (random) in one direction or both 	Mechanical couplings not rigid Air in the solenoid of the proportional valve Proportional valve defective due to wear or dirt	Driver's bias current not correct Electromagnetic disturbances
Self amplifying oscillations 	Hydraulic hoses too elastic Mechanical couplings not rigid Too high Δ pressure across prop. valve Too high hydraulic proportional valve gain	Axes card proportional and integral Gains too high

6.3 Closed loop applications - dynamic conditions: step response

PROBLEMS		CAUSES OF THE FAULTS	
		Mechanical/Hydraulic	Electrical /Electronic
Overshoot in one direction		Too high Δ pressure across valve	Axes card Derivative Gain set too low
Overshot in both directions		Mechanical couplings not rigid Hoses too elastic Proportional control valve mounted too far from the actuators	Axes card Proportional Gain set too high Axes card Integral Gain set too low
Slow approach to set		Pressure Gain of the proportional control valve too low	Axes card Proportional Gain set too low Driver's Bias current not correct
Drive unable to reach the set		Insufficient hydraulic pressure or flow	Axes card Integral Gain set too high Proportional and Derivate Gains set too low Driver's Scale and Bias not correct
Unstable control		Actuator's feedback transducer connection intermittent Hoses too elastic Air in the solenoid of the proportional valve to high friction	Proportional Gain set too high Integral Gain set too low Electrical noises
Inhibited control		Actuator's feedback transducer mechanically uncalibrated Lack of hydraulic power	Lack of electrical power Lack of reference or feedback signal Cabling error
Bad repeatability and high hysteresys		Actuator's feedback transducer connection intermittent	Axes card Proportional Gain set too high Integral Gain set too low

6.4 Closed loop applications - dynamic conditions: frequency response

PROBLEMS		CAUSES OF THE FAULTS	
		Mechanical/Hydraulic	Electrical /Electronic
Amplitude damping		Insufficient pressure and flow	Axes card Proportional Gain too low Driver's scale adjustments set too low
Wave amplifier		Hoses too elastic Proportional control valve too far from drive	Driver's scale adjustment not correct
Time delay		Insufficient pressure and flow	Ramp time inserted Axes card derivative gain set too low
Vibrating control		Air in the solenoid of proportional valve	Axes card proportional and Derivative Gains too high Electrical noises Derivative Gain set too high