Bulletin 5715-613/UK - Preliminary Information

Conversion Manual

Series VRD350/355 to Series PxD

Electronic for Proportional Valves

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Replacement of Electronics Series VRD 350/355
by Module Types Series PxD

Notice

For conversion of a present system installation the subsequent items has to be noticed:

- For the electronic series VRD350/355 there was an open and a closed loop version.
  The open loop version has been served as solenoid driver of a proportional valve without position transducer.
  The closed loop version consisted of one control loop and has been served either for solenoid driving plus position control of a proportional valve with position transducer (internal closed loop) as well as for driving a solenoid without position transducer plus control of a system side process value, i.e. position, pressure, force (external closed loop).

- In most cases the electronic series VRD350/355 may be replaced by the PxD series, but the both series are not connector compatible and have limited function compatibility.

- A preliminary investigation is required, if (resp. with which device) a replacement of the present VRD-electronics may be possible.

- The following types may be usable as replacement for the currently used VRD-electronics:

PWD00A-400	Electronic for open loop proportional directional control valves
PWDXXA-400	Electronic for closed loop directional control valves with internal position control resp. open loop proportional directional control valves with external position control loop.
PCD00A-400	Electronic for open loop proportional pressure / flow valves.
PZD00A-400	Additional electronic for command signal processing (internal commands, ramps, special features)

- Before starting the conversion work, reading of the operation manual is essential!
  Suggestions for the conversion can also obtained from the wiring examples below.

☞ The wiring diagrams represents only examples. Because of the varied usability different circuits are possible.

- For usage of the electronic PWDXXA-400 with external control loops the required control parameters has to be determined. A conversion from the currently used VRD-parameters is not possible. Suggestions for the controller tuning are also available from the chapter "PWDXXA-400 for external control loops".

⚠ The conversion work may only be carried out by qualified personnel with electrotechnical education! In case of insecurity please consult the factory.

△ Check the usage of a pre-fuse! Each module requires its own pre-fuse according to the technical data, which can obtained from the operation manual.

Comparison of Basic Features of Electronics Series VRD350/355 and PxD

Applications without closed loop control (open loop)

	VRD 350/355-x	PWD/PCD00A-40x
Design	Euro card	Rail mounting module
Functionality	Valve specific, valve parameters fixed	Universal function, valve parameters from software library
User software	Application parameters from PC via user software ProVRD	Application parameters from PC via user software ProPxD
Operating system	MS-DOS	from WINDOWS 95
Supply voltage	18...30VDC	18...30VDC
Solenoid current ranges	0,8 / 2,7 / 3,5A	0,8 / 1,3 / 1,8 / 2,7 / 3,5A
Current consumption	max. 2,0A	max. 2,0A
Pre-fuse	1,6 / 3,15A fast	2,5A medium lag
Ambient temperature	0...+50°C	-20...+60°C
Connection	DIN 41612F, 48-pole	Screw terminals, disconnectable
Weight	220g	160g
Command signal inputs	0...+/- 10V	0...+/- 10V
Command signal differential input	yes	PWD: yes PCD: no
Reference output for potentiometer supply	+/- 10V (10mA)	+/- 10V (15mA) via additional module PZD00A-40x
Recall internal commands	4 channels	4 channels
Direction switch over	2 times +/-	no
Ramp switch off	yes	no
Enable input	0/30V (10mA)	0/30V (0,3mA)
Status output	0/30V (50mA)	0/30V (15mA)
Data interface	RS-232C via null modem cable	RS-232C via null modem cable

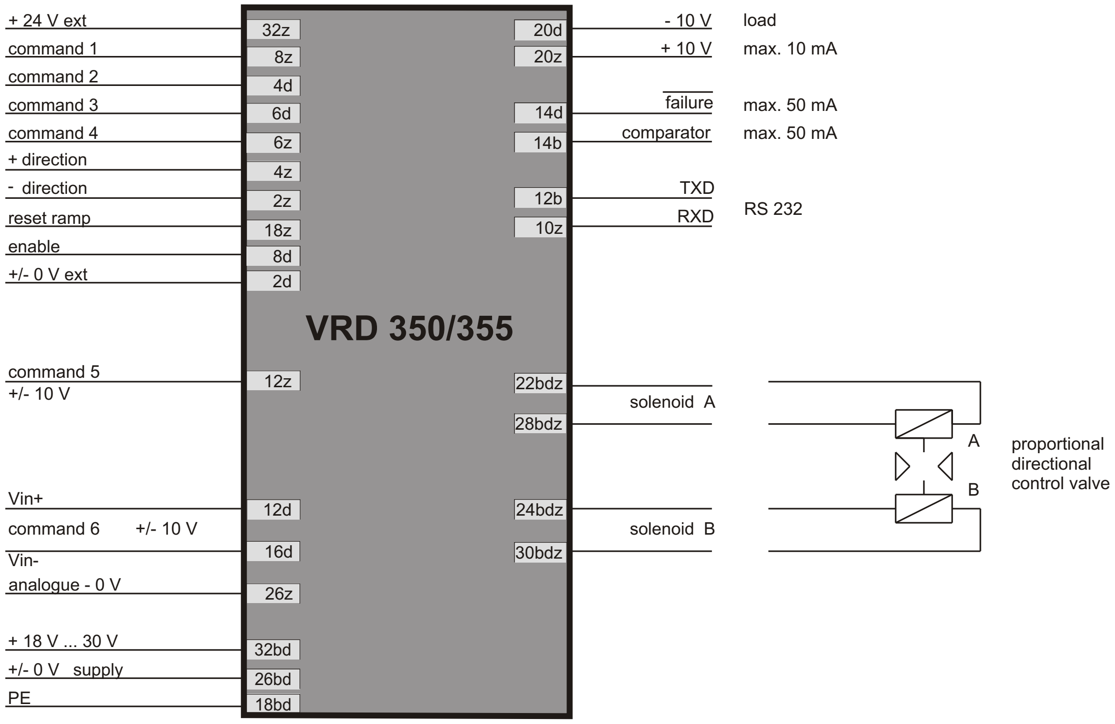
Comparison of Basic Features of Electronics Series VRD350/355 and PxD

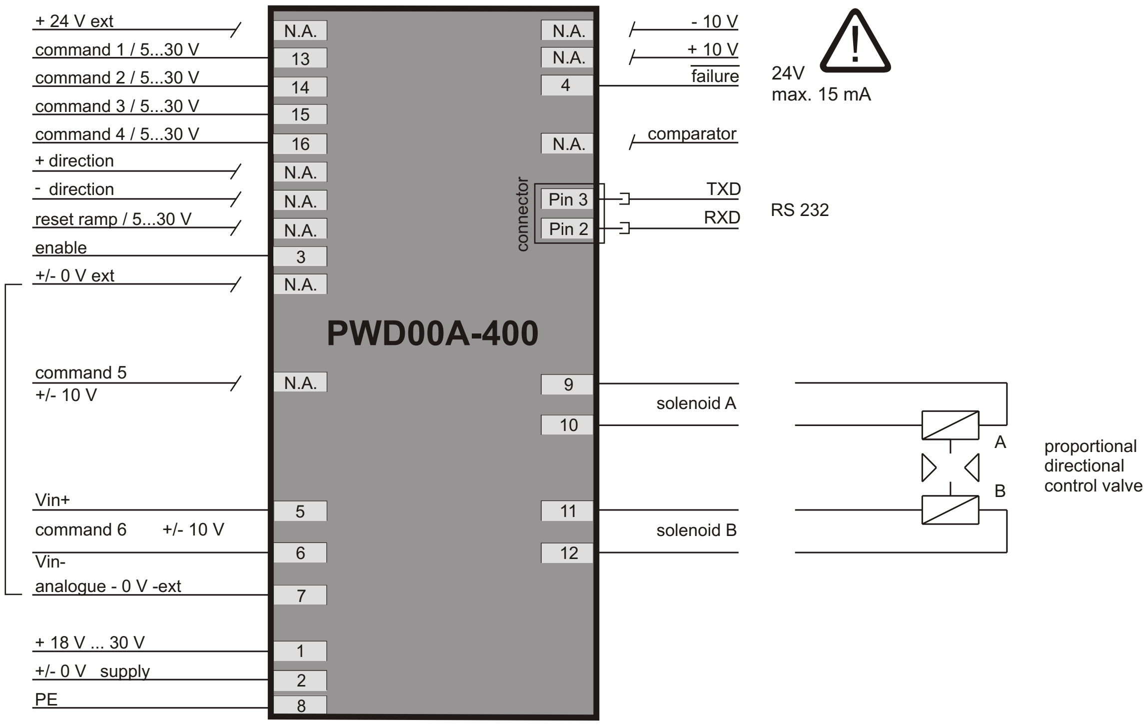
Applications with closed loop control internal or external

	VRD 350/355-x	**PWDXXA-40x**
Design	Euro card	Rail mounting module
Functionality	Valve specific, valve parameters fixed	Universal function, valve parameters from software library
User software	Application parameters from PC via user software ProVRD	Application parameters from PC via user software ProPxD
Operating system	MS-DOS	from WINDOWS 95
Supply voltage	18...30VDC	18...30VDC
Solenoid current ranges	0,8 / 2,7 / 3,5A	1,3 / 2,7 / 3,5A
Current consumption	max. 2,0A	max. 2,0A
Pre-fuse	1,6 / 3,15A fast	2,5A medium lag
Ambient temperature	0...+50°C	-20...+60°C
Connection	DIN 41612F, 48-pole	Screw terminals, disconnectable
Weight	220g	160g
Command signal inputs	0...+/-10V	0...+/- 10V 0...+/- 20mA / 4...20mA
Command signal differential input	yes	yes
Reference output for potentiometer supply	+/- 10V (10mA)	+/- 10V (15mA) via additional module PZD00A-40x
Feedback signal inputs	Valve specific as well as 0..10V / 0..+/- 10V 0..20mA / 4..20mA	Valve specific as well as 0..10V / 0..+/- 10V 0..20mA / 0..+/- 20mA / 4..20mA
Feedback signal differential input	no	yes
Recall internal commands	4 channels	6 channels via additional module PZD00A-40x
Direction switch over	2 times +/-	no
Ramp switch off	yes	no
Enable input	0/30V (10mA)	0/30V (0,3mA)
Status output	0/30V (50mA)	0/30V (15mA)
Monitor output	0...+/- 10V (5mA)	0...+/- 10V (5mA)
Comparator output	0/30V (50mA)	via monitor output 0..+/- 10V (5mA)
Data interface	RS-232C via null modem cable	RS-232C via null modem cable

Rewiring VRD350/355 to Series PxD

for Open Loop Proportional Directional Control Valves
Input Signal Analogue & Internal Command Recall



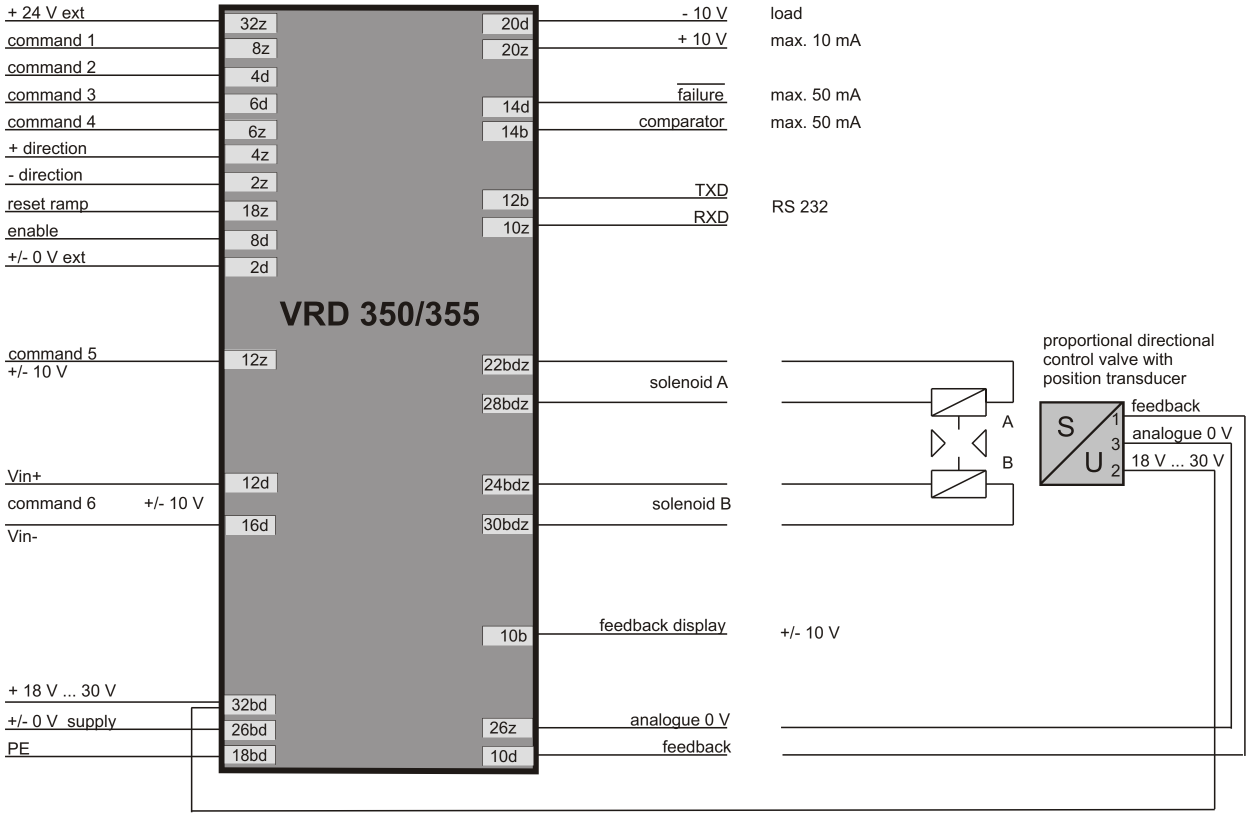


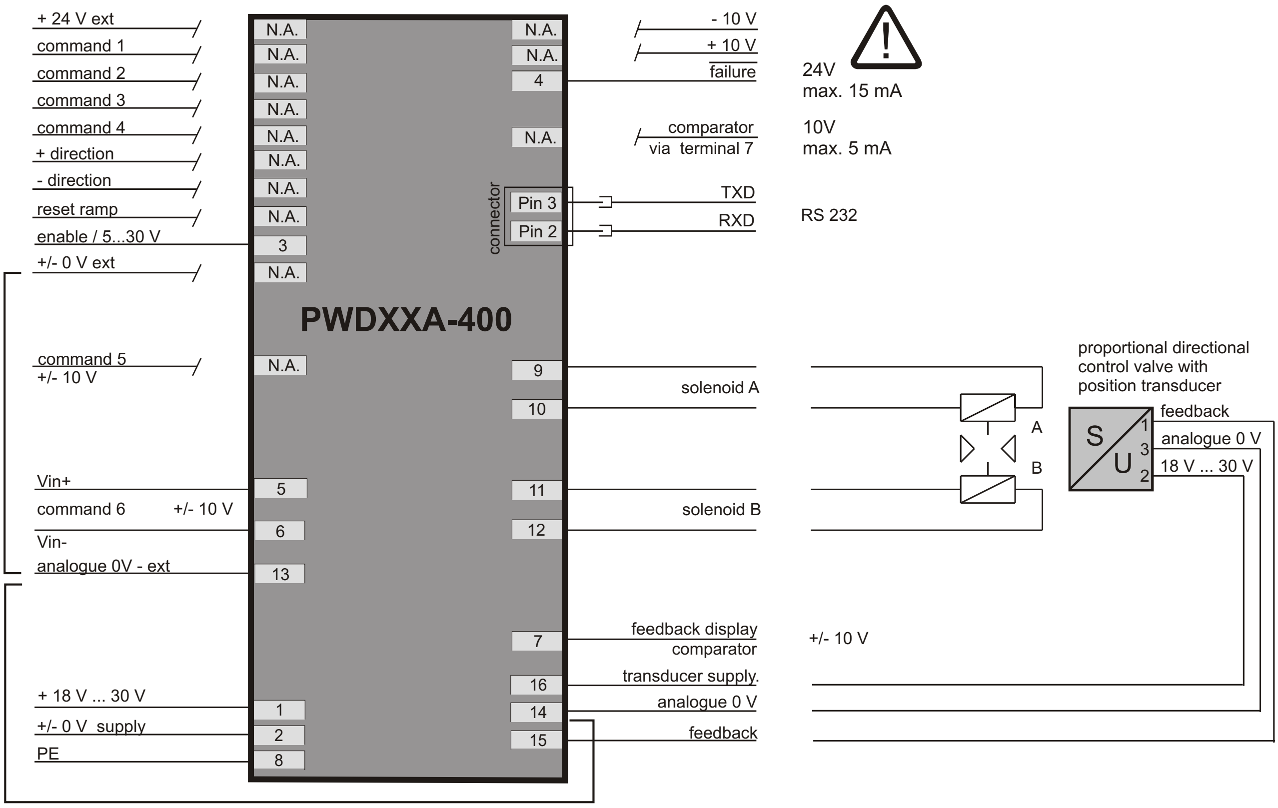
N.A. = not available

⚠ This wiring diagram represents only a proposal.
The user is responsible for the final verification of the connection order.

Rewiring VRD350/355 to Series PxD

for Closed Loop Proportional Directional Control Valves
Input Signal Analogue





N.A. = not available

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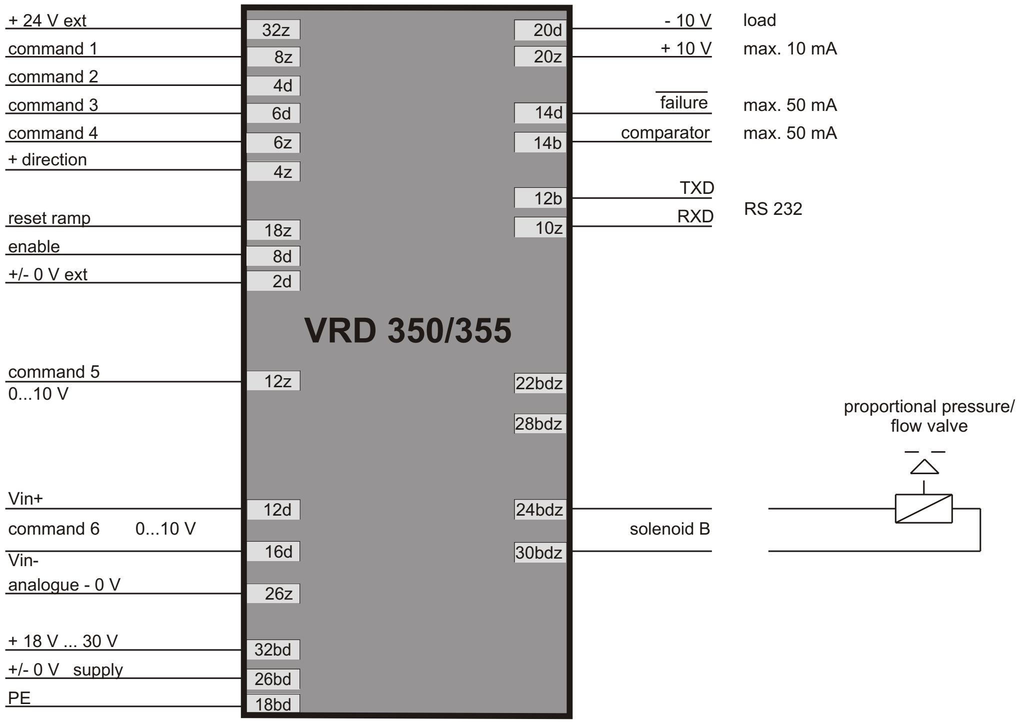
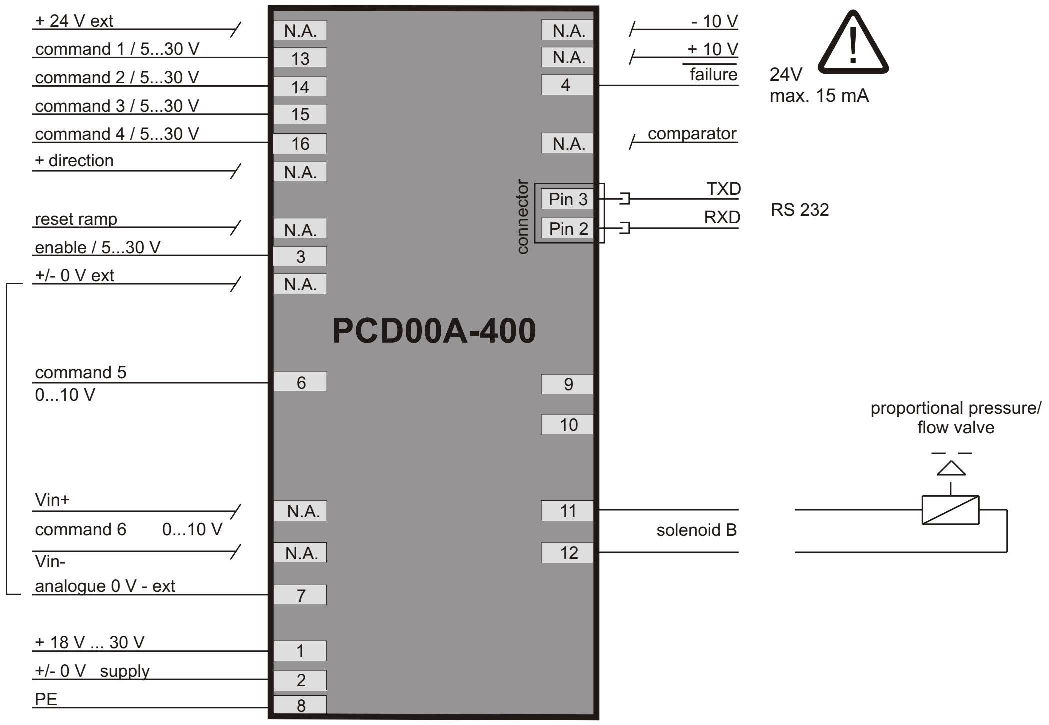
Rewiring VRD350/355 to Series PxD

for Open Loop Proportional Pressure/Flow Valve
Input Signal Analogue & Internal Command Recall





N.A. = not available

This wiring diagram represents only a proposal.
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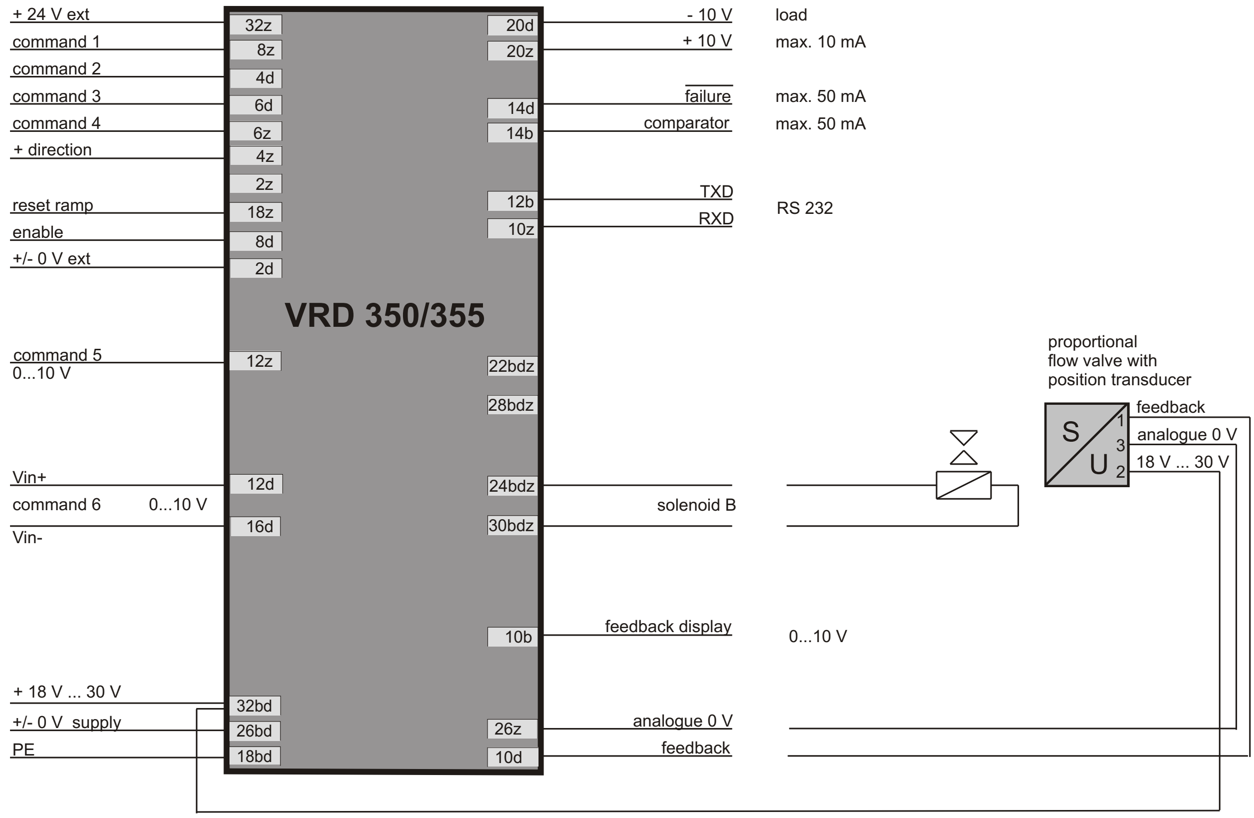
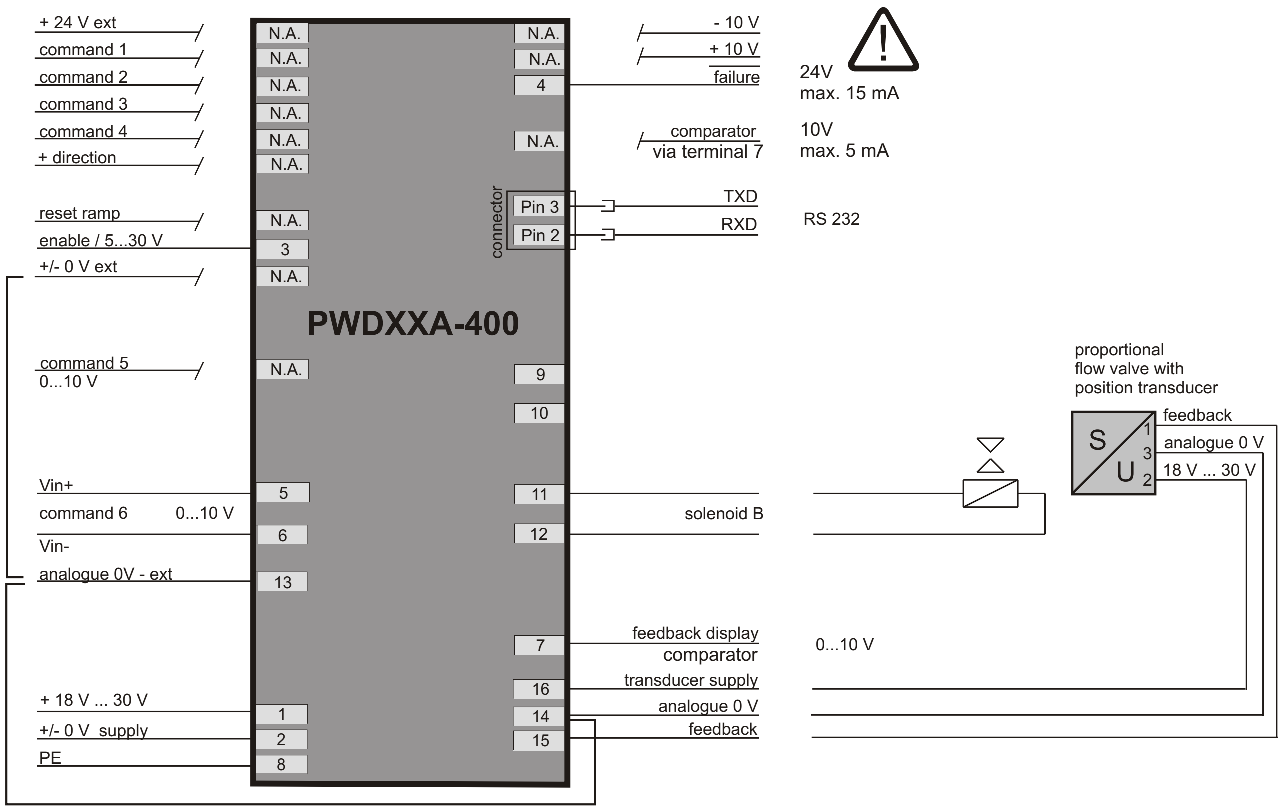
Rewiring VRD350/355 to Series PxD

for Closed Loop Proportional Flow Valve
Input Signal Analogue





N.A. = not available

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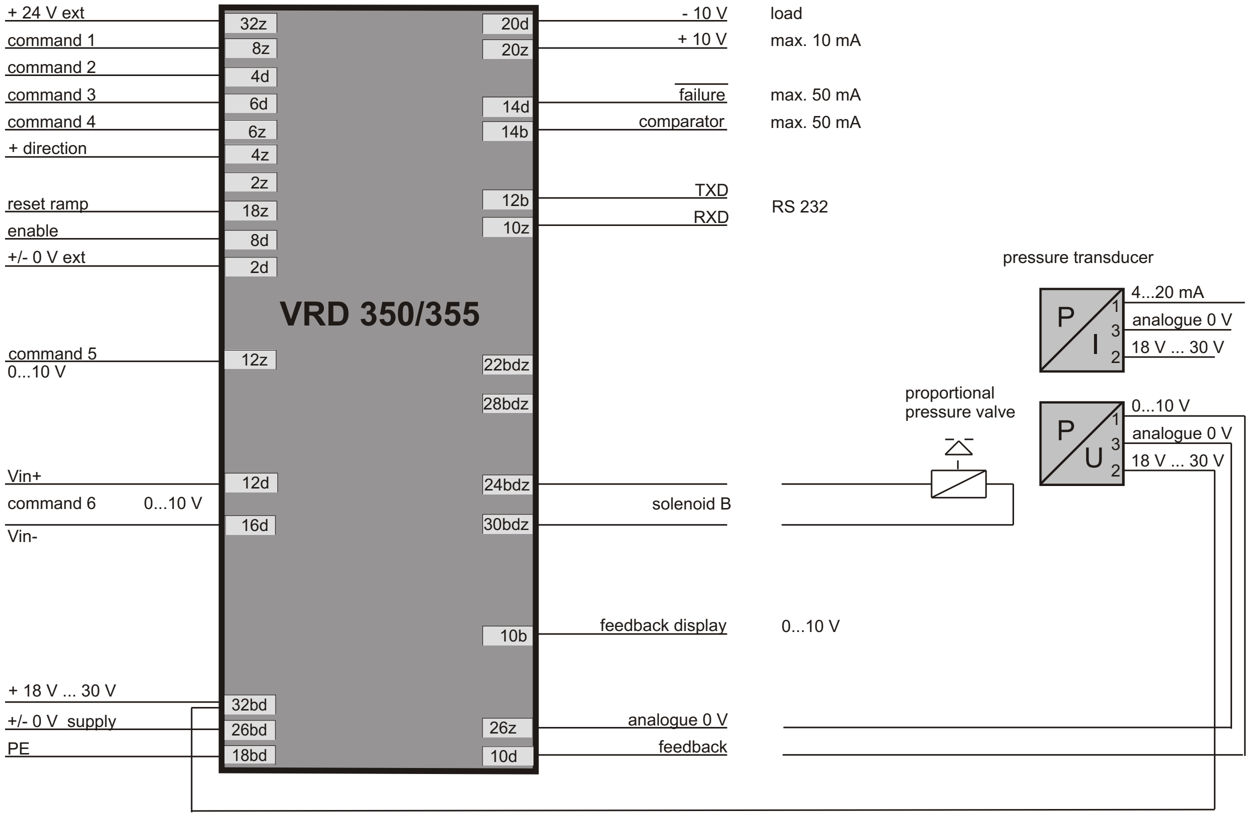
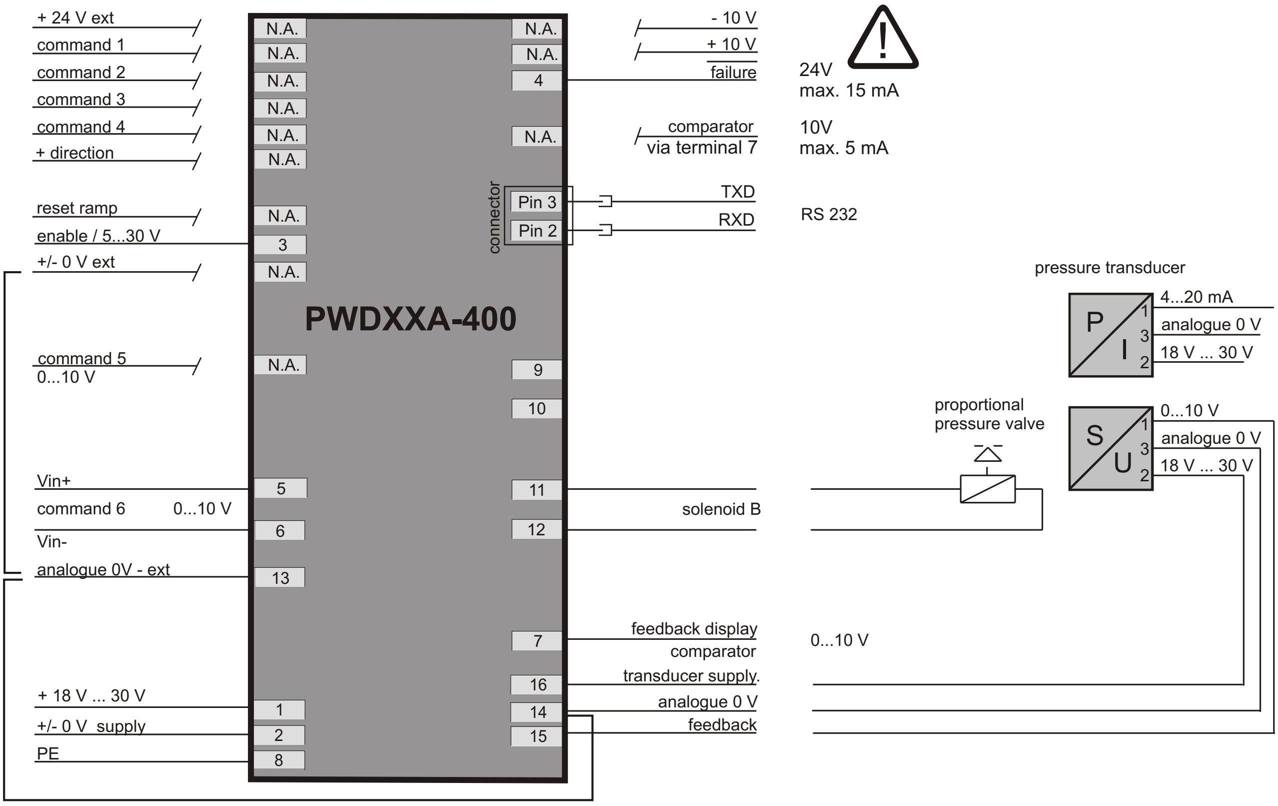
Rewiring VRD350/355 to Series PxD

for Proportional Pressure Valve with External Closed Loop Pressure Control
Input Signal Analogue





N.A. = not available

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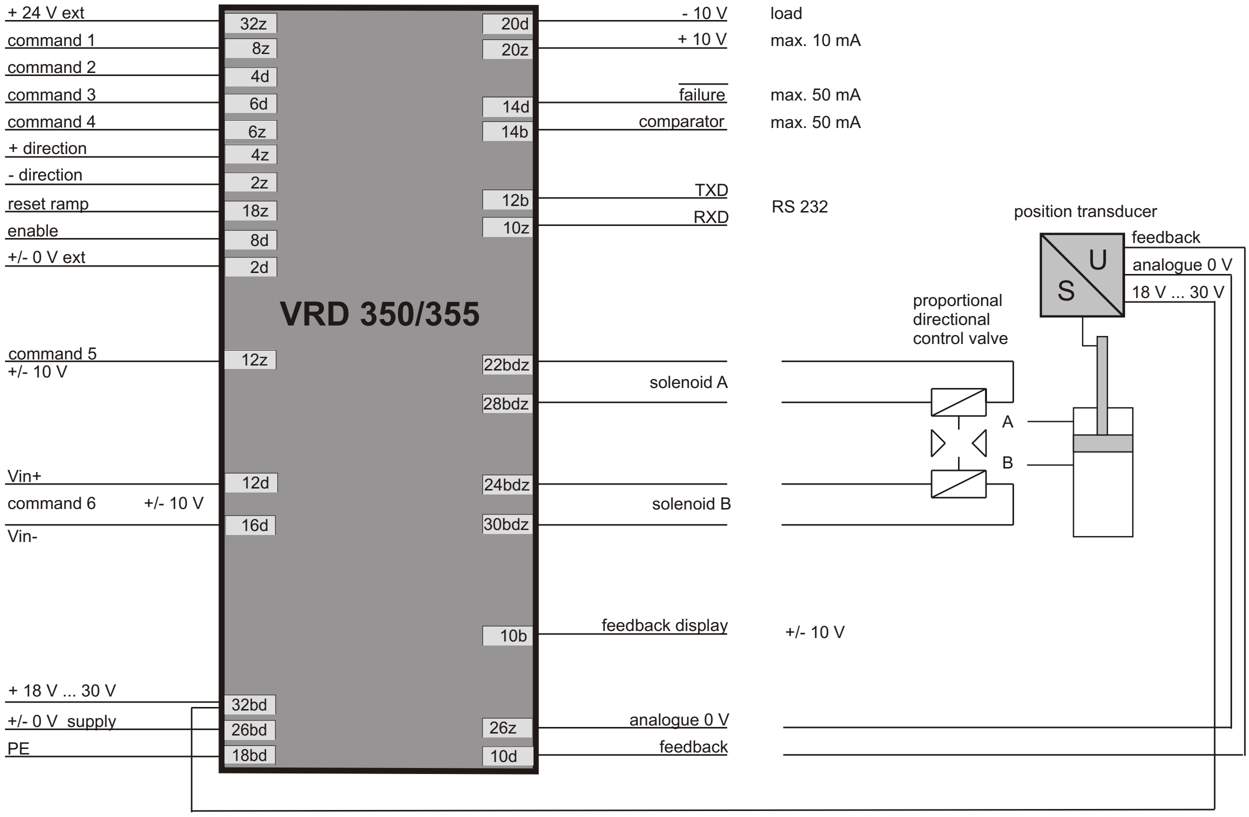
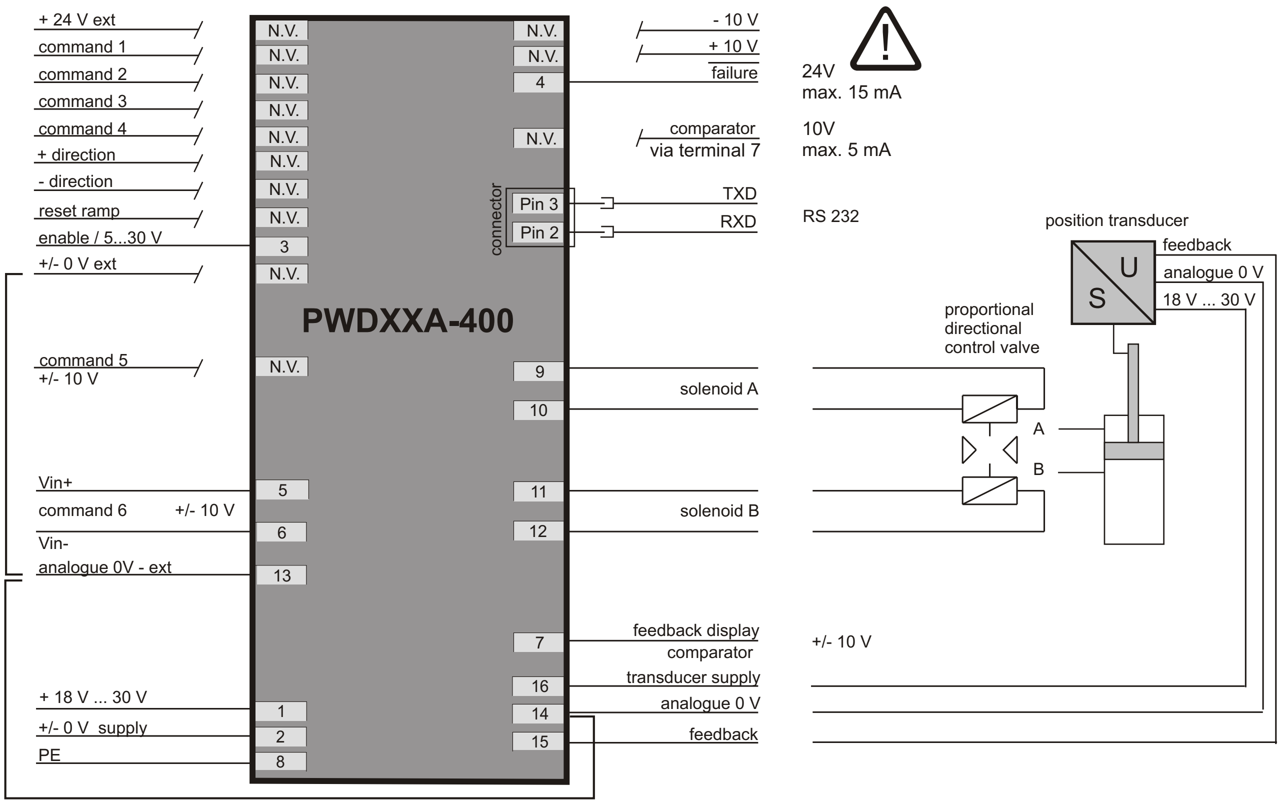
Rewiring VRD350/355 to Series PxD

for Proportional Directional Valve with External Closed Loop Position Control
Input Signal Analogue





N.A. = not available

⚠ This wiring diagram represents only a proposal.
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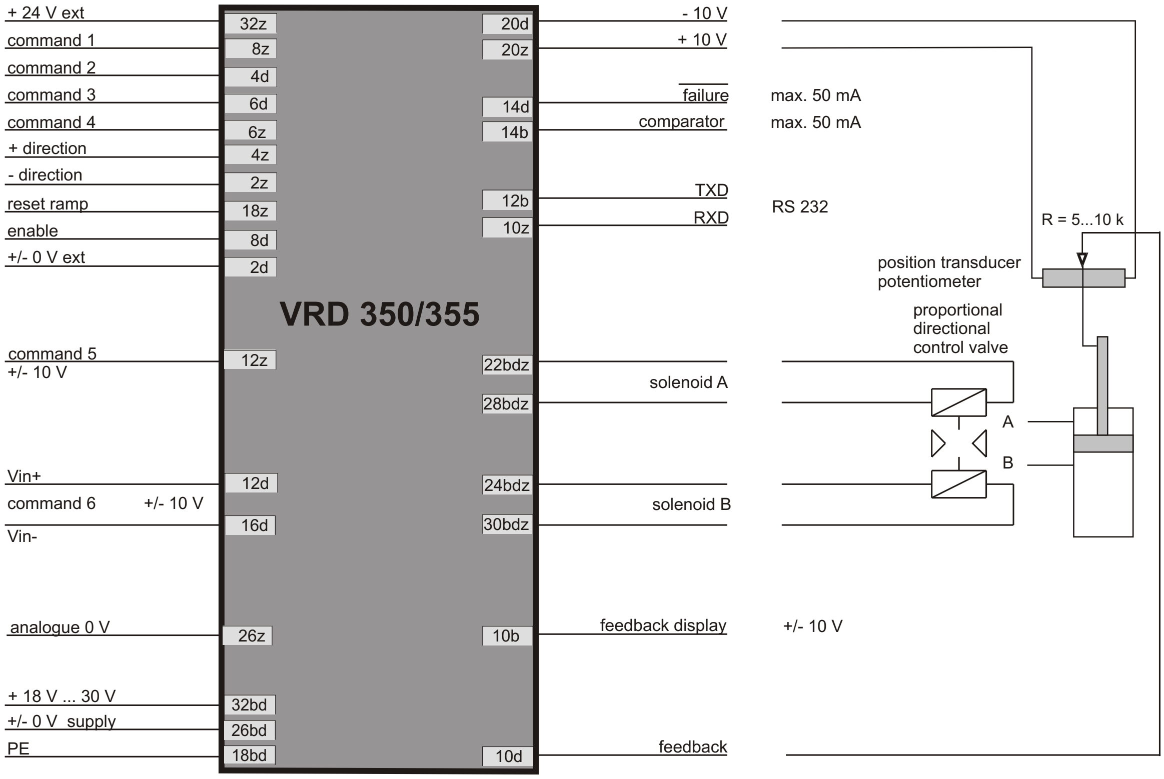
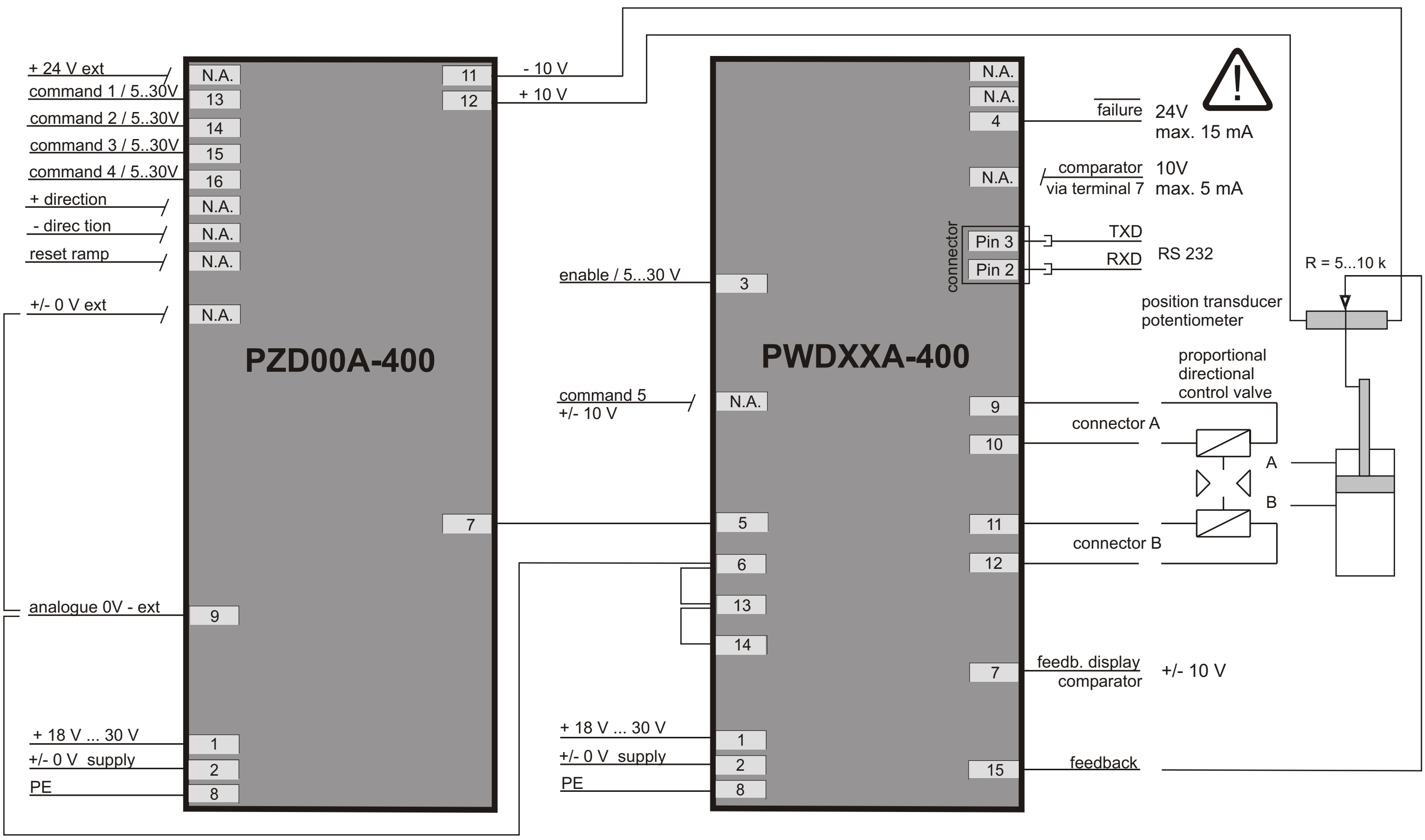
Rewiring VRD350/355 to Series PxD

for Proportional Directional Control Valves with External Closed Loop Position Control
Internal Command Recall & Feedback-Potentiometer





N.A. = not available

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PWDXXA-400 for External Position Control Loops.
Guideline for controller tuning.

Introduction

The PWDXXA-400 uses a feedback control loop which automatically adjusts the electrical input to the valve solenoids to move the drive to the commanded position. At the heart of this feedback loop is a digital controller which computes and updates the solenoid output every one millisecond. The controller has adjustable coefficients, which must be set by the user for the particular application.
The controller provides a standard PID control capability plus extra features you can use to improve the performance beyond the limits of PID.

Basic information for the control algorithm

Why tuning?

The controller can be used with valves that vary greatly in flow capacity, frequency response, saturation and deadband, with different kinds of load, and with cylinders of any area and stroke. The user must adjust the control coefficients for their specific system. There is no fixed set of values for the controller coefficients that will handle every situation well.
The electronic uses a "PID" controller for its basic control action. The name PID comes from the fact that the controller output is the sum of three terms, called proportional (P), integral (I) and derivative D), each with a user adjustable coefficient. The user software provides therefore the parameters P16 (P), P17 (I) and P18 (D).

P - P16

This term provides an immediate output signal, proportional to the error between commanded and measured position. If this parameter is set too high, sustained oscillations may occur. If it is set too low, accuracy and speed of response may be poor.

I - P17

This term causes the output to change at a rate proportional to the error in measured position, in a direction to drive the steady state error to zero. Use P17 to reduce position error when the actuator is stationary. Too high a value of P17 causes oscillations, with too low a value it may act too slowly.

D - P18

The D-term provides an output to the valve proportional to the rate of change of the measured drive position. Depending on the polarity of the parameter prefix, this term causes damping or accelerating. For hydraulic drives this term should be set to a very low value.

Parameter ranges

The controller provides two parameter ranges, of course the operating modes *BASIC* and *EXPERT*. For internal closed loop control of a valve, the control coefficients may be simply loaded from the valve library, but external closed loop control requires an application specific setting of the control coefficients via the *EXPERT* mode. The operating mode may be selected via the menu *OPTIONS*.

Simple tuning of a position control loop

Before trying anything complicated, you should adjust the proportional gain, accessible by P16. In many cases this coefficient will be all you need, and you will not have to bother with any of the other control features. If you do need the other features, you cannot adjust them properly without first adjusting the P-gain. Adjusting the P-gain is done by setting all the other control coefficients P13 – 19 as well as P26 –27 to zero and increasing P16 to the highest value that does not result in sustained oscillations of the cylinder position.

Guarantee of control functionality
Before the tuning of the control loop may be started, the functionality of the control circuit must be ensured. As previously mentioned, the controller compares command and feedback signal and adjusts the electrical input to the valve solenoids to move the drive to the commanded position. To ensure this functionality, the polarities of command and feedback signal must be equal.

How can the functionality of the control loop be achieved?
At first you should set off the control loop (set parameter E2 to value 0 = open loop and transmit to the electronic) and cause the drive via manual control to the middle of the cylinder stroke. Afterwards adjust at first the control coefficients as described in chapter "Simple tuning of a position control loop" (P16 at 10%) as well as the parameter E2 at 2 = external closed loop and transmit to the electronic. If this results in a jump of the drive into an end position, the polarities are incorrect. Access now the parameter P12 = feedback signal polarity, change the value and transmit the data. By now the drive should be adjustable and must remain in its position when you switch on the closed loop control via parameter E2. Now you should preset position commands and supervise the drive movement. If the drive even tough is running in closed loop mode, but the direction of the movement is not as required, you have to change the polarities of both command and feedback signal via the parameters P11 and P12. After that the drive is running as desired, you can continue with tuning of the loop.

Tuning of the closed loop control

1. Create a suitable tuning test profile – otherwise it may be difficult for you to tell how good the system response is (the test profile may also be generated by an upstreamed electronic module PZD00A-400). The test profile should start causing the cylinder drive to move from the start position with the desired maximum acceleration and velocity to the required final position. At the final position the drive should remain for a while, that will give you enough time to watch the load position to see if it oscillates or remains stationary. This should be followed by returning of the drive to the start position, where the hold in position may also be evaluated.
2. Check once more to be sure that P17 and P18 are set to zero.
3. Adjust P16 to a low value, i.e. 10%, and try the system on the test profile. Observe the result of the test. There are three possible outcomes:
   - *The cylinder oscillates continuously*
     Stop the system quickly. Reduce the P16-value to ½ of the initial guess, and try again.
   - *The cylinder overshoots, but stops after one or two oscillations*
     Reduce the P16-value to ¾ of the initial guess, and try again.
   - *The cylinder reaches the commanded position with no overshoot*
     The system is usable with the estimated value of P-gain. You should experiment with stepwise increasing of the P16-value to see how high a value the system will tolerate. Accuracy and response are improved by high values, but do not allow permanent oscillation!
4. You have now completed the basic tuning for your control loop. The next step is to test the performance of the system to see if it meets your requirements. If not, the electronic has additional control features you can use to improve performance, as explained below.

Problem	Solution
Position error too large, when drive is stationary	Use parameter *P17 = I-gain*
Repeatable position error by using a valve with overlapped spool	Use deadband compensation feature *P7 = MIN channel A* resp. *P8 = MIN channel B*
Position error too large when following constant velocity position command	Use parameter *P13 = bypass gain*
Slow, small amplitude, position oscillation	Use integrator window *P26 = window I-gain*
Dissapointingly low P-gain	Check the frequency response of valve and position transducer, and the drive resonant frequency (s. items below)
Response too slow	Be sure P16 = p-gain is adjusted high enough (s. also previous items)
Inexplainable problems	Check the setting of all parameters

<u>Improving system performance</u>

Using the parameter P17 = I-gain
The integrator gain (abbreviated I) can be adjusted to reduce or eliminate the error between the commanded position and the position measured by the feedback transducer, when the command is remaining constant. Higher values of I-gain will cause the response to be longer and more oscillatory, but reduce the stationary error. Lower values will require a longer time to reach zero steady state error.

Eliminating a slow, small amplitude oscillation in position
Because of friction and other imperfections, use of the I-gain sometimes causes a slow, small amplitude oscillation in load position. This is an entirely different problem from the vigorous oscillations that occur when the P-gain is set too high. The electronic provides a "Window" feature (sometimes called "in-position-window") to solve this problem. Select the parameter P26. Stepwise increasing of the window size to a large enough value will stop the slow oscillations.

Position error too large because of repeatable deadband or hysteresis
You can use the integrated deadband compensation coefficient to compensate for this. There are separate adjustable parameters P7 and P8 for both valve sides. This feature generates constant correction signals which will be active for the dedicated valve site if a signal occurs on the command signal input. As a result this will cause the valve to immediate pass through the overlap region.

Reducing following error when moving at constant velocity
Hydraulic actuators have an inherent error when following constant velocity commands. You can use the Bypass-gain feature P13 to compensate for this error. For adjustment of this parameter you will need to create a suitable test motion profile consisting of a longer constant velocity phase. Increasing of the Bypass gain causes reducing of the following error.

Increasing load stiffness
"Load stiffness" is the term for the resistance of the servo loop to cylinder deflection by external forces. Adjusting P16 to the highest practical value is important.

Dissapointing control loop function
The higher the value of P-gain that can be used, the better is the static and dynamic performance of the system. You may not have any direct need for fast response, but may still need a high value of P to reduce static error, reduce following error or increase actuator stiffness. High values of P cause faster system response, whether you need it or not. As the system frequency response gets too close to the frequency response of one of your components, the system response becomes oscillatory.

- *Valve*
  The frequency response of the valve can be obtained from the datasheets. As a first guess, it needs to be at least twice the system frequency response.
- *Position transducer*
  Some analog output transducers will present problems because of filtering intended to smooth the output. To ensure best system dynamic, sensors with integrated D/A-converter should operate with a most high sampling rate. Magnetostrictive transducers with digital output often have a low sampling rate, because an interaction with the achievable resolution. Please obtain detailed information from the transducer supplier.
- *Drive*
  There is a mode of mechanical vibration created by the mass of the load and the compressibility of the hydraulic fluid in the whole system. This frequency is often surprisingly low when using long stroke cylinders.

Update rate of the controller
The controller updates the electrical output to the valve at 1000Hz. This rate is fast enough to have negligible effect in almost all hydraulic applications, but it does set an absolute limit on the response of the system.

Position transducer accuracy and resolution

A control system is no better than its transducer. Here are points to watch for:

- *Absolute accuracy*
  The controller positions the load as closely as possible to the position measured by the feedback transducer. The absolute accuracy of the measured position is determined by the transducer.
- *Resolution*
  The electronic cannot position the load more accurately than the resolution of the transducer. Be sure the resolution of your sensor is adequate. When using a true analog transducer (analog measurement principle and analog output), the resolution is limited by the utilized A/D-converter, which is 12 bit (1/4096 = 0.025 %).
- *Installation*
  The installation of the position transducer plays a most important rule for the proper functionality of the closed loop control. By all means it has to be secured, that the mounting of transducer and actuating device provides absolute freedom from vibration and clearance effects. This is most important even for the commonly expected velocities and accelerations. Also, the transducer has to be laid out for the dynamic requirements.