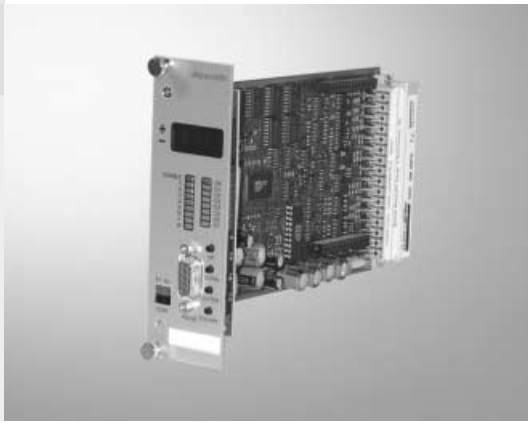
Rexroth
Bosch Group

Digital Injection and Ejector Axis Control for Hydraulic Injection Molding Machines

RA 08 421/09.03 **1/**10
Replaces:
RA 08 421/06.03

Model VT-HACD-DPQ-2X



Series 2X

Features

- Accepts digital SSI position feedback devices
- Six analog inputs predefined, voltage (±10V, 0..10V)
- Three analog outputs predefined
- Enable input and Card OK output
- Eight predefined digital inputs
- Seven predefined digital outputs
- Optimization of the hydraulic axis. Valve configuration parameters are available to adapt the output for a wide range of hydraulic valve types
- ±10V output
- Front display for parameter display and 4 pushbuttons to access various parameters
- Serial interface RS232
- DeviceNet™ communication

Available accessories:

- PC program BODAC available on CD-ROM or internet download
- Interface cable: Cable set VT-HACD-1X/03.0/HACD-PC or standard 1:1 cable

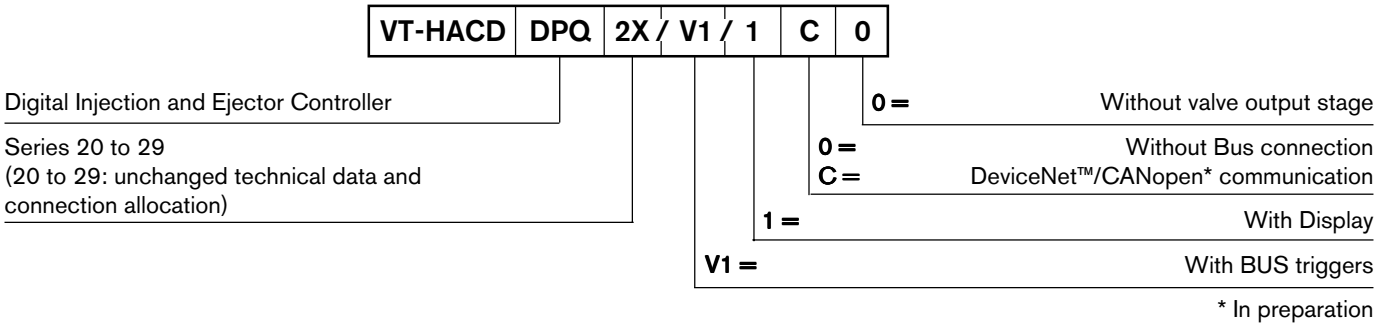
Further information:

- Product information see RA 08421-P
- Installation instructions see RA 08421-B

Suitable card holders:

- 19” rack VT 19101, VT 19102, VT 19103 or VT 19110 (see RE 29 768)
- Open card holder CH64G-1X (RA 29 921) suitable for cabinet mounting only
- Connection adapter VT 10812-2x/64G (see RE 30 105)

Model code



Functional description

The DPQ is a digital control card for injection molding control type applications. It includes proven control techniques and advanced options for controlling the hydraulic axis. Ultimately, the control system is bound to the mechanical and hydraulic limits of the machine. The DPQ is a tool for closed loop control that can define the performance limits of the machine. Results are a function of proper machine design, installation, environment and laws of physics.

Overview

The DPQ is a digital platform, industrial injection molding controller. It optimizes the control of a hydraulic injection axis and/or a hydraulic ejector axis.

- Injection velocity profiles are controlled completely by use of closed loop position control. An advanced position command profile is calculated automatically based on the operator input velocity profile.
- Ejector profiles are controlled in either open or closed loop, depending on the hydraulic configuration.
- Because the DPQ is a position control device it requires a position feedback transducer. Both 0 to 10 VDC analog and SSI digital types are supported for the injection axis.
- The DPQ includes injection force-limiting control that can be configured to work with 1 or 2 pressure transducers or a load cell.
- The injection velocity and pressure profiles may be controlled with one proportional directional type hydraulic valve or separate valves for flow and pressure.
- The DPQ includes DeviceNet™ communications protocol that allows access to all parameters directly from a PLC or computer. All sequence triggers are transmitted to the DPQ over a DeviceNet™ bus system.
- Motion profile set points are normally transferred into the DPQ from a PLC or computer. The profile set points may also be entered into the card using Bosch Rexroth BODAC software.
- Critical process data is acquired and stored during each cycle. The stored data is available for machine controller statistical process control functions through the DeviceNet™ communications link.

Operational Description

The DPQ is a complete hydraulic injection axis and ejector axis control solution. An injection profile and an ejector profile are created from parameters that are entered by the machine operator into a machine sequential logic controller. Parameters are loaded from the machine sequential logic controller into the card through a DeviceNet™ communications interface. All injection cylinder and ejector cylinder process parameters are then stored on the card. Parameter changes may be individually loaded into the card, or the entire profile loaded at one time. The card maintains the last saved profile in nonvolatile flash memory. A single injection profile and ejector profile is stored on the card. Multiple profiles may be stored in the machine sequential logic controller and any one selected to load into the card. Handshaking to sequence the axis control is through the DeviceNet™ communications interface. A single discrete input is required to enable the card prior to any other commands.

Injection Control

Mold Fill Profile

A velocity profile of up to five steps is provided to fill the mold cavity. A maximum pressure limit may be set for each profile step. A timer is available to delay the start of the velocity profile and allow the hydraulic pump system time to build pressure, which prevents undesirable initial windup of the closed loop control.

The velocity profile is controlled by implementation of closed loop position control of the injection cylinder. At the start of inject forward the internal position command is set equal to the current cylinder position feedback and then ramped forward at a rate of movement corresponding to the velocity command in the current profile step. Each step in the profile is initiated when the internal position command reaches a position as defined in the profile. Repeatability of the profile is determined by adjusting the proportional gain as high as possible so the injection cylinder closely follows the internal position command under varying load conditions. This type of system is used because it is relatively unaffected by change in plastic material property or temperature. Because the position control loop is a ramp of position command over time, change of velocity between the profile steps is seamless and does not require any extra ramp adjustments.

Functional description (continued)

Transfer to Hold Pressure

The card begins the hold pressure profile when any of the pre-determined transfer criteria are achieved. Transfer criteria available in the stored profile in the card are hydraulic pressure, cylinder position, and mold cavity pressure. All of the transfer criteria are continuously monitored, so any criteria not used are set to a value that will not be reached during the mold fill velocity profile. Hydraulic pressure transfer is enabled only if the injection cylinder position is less than the hydraulic transfer position parameter. This allows the initial acceleration pressure to be higher than transfer pressure without triggering the hold pressure profile. The machine sequential logic controller may also initiate transfer based on any other external event by turning on either a DeviceNet™ trigger or a discrete input. An external event could be a timer or third party process-monitoring device. Repeatability of transfer by the stored profile is 2 milliseconds. The card signals to the sequential machine logic controller when transfer has occurred.

Hold Pressure Profile

A pressure profile up to five-steps long is available for pack and hold. Once the hold profile is initiated the card changes mode into open loop velocity limiting with pressure override. Any remaining steps in the velocity profile are ignored. Each step in the pack and hold profile has adjustable pressure, time, velocity limit, and rate-of-pressure-change set point. Step 1 in the profile is started at time of transfer. Each subsequent step in the pack and hold profile is initiated when the previous step timer is finished. The velocity limit in step 1 of the pack and hold profile is typically used to prevent the injection cylinder from lunging forward to build pressure when transfer by position is used. It also allows the card to react faster when transfer by hydraulic or mold cavity pressure is initiated, by closing down the flow valve command to a smaller opening within 2 milliseconds of transfer, preventing pressure overshoot. The velocity limit in subsequent pack and hold profile steps is typically set higher so it does not limit the dynamic response of the pressure control loop.

Pre-Decompress

After the last timer is completed in the hold pressure profile the card automatically decompresses the screw. Pre-decompress is active if the pre-decompress position parameter is greater than the actual injection cylinder position at the end of the pressure profile. The pre-decompress velocity parameter is an open loop valve command. Pre-decompress is complete once the injection cylinder position is equal to or greater than pre-decompress position parameter. At the end of pre-decompression the card raises a signal to the machine sequential logic controller that decompress is complete. The valve outputs are set to zero volts at end of pre-decompress.

Recovery Profile

To begin recovery the machine sequential logic controller raises the recovery trigger. The card then controls the injection unit recovery based on the position, velocity, and pressure parameters in a 2-step recovery profile. Back pressure is closed loop control with a open loop velocity limit. The second step in the recovery profile is triggered by the increasing injection cylinder position as recovery continues. When applied to a single injection valve hydraulic circuit the velocity parameter for each back pressure step is set as a forward valve opening limit. When applied to a hydraulic circuit which uses a separate back pressure proportional relief valve the velocity parameter can be set to whatever valve command is necessary for the injection directional proportional valve, for example screw motor speed on some hydraulic systems.

Screw recovery mode is complete when the injection cylinder position is equal to or greater than the shot size parameter. When shot size is reached the card will signal to the machine sequential logic controller. Back pressure control will be maintained until post decompress begins.

Post Decompress

When the post decompress trigger is raised the DPQ will begin post decompress mode if the injection cylinder position is equal to or greater than shot size. Post decompress is active if the post decompress position parameter is greater than the injection cylinder position at the end of the recovery mode (typically shot size). The post decompress velocity parameter is an open loop valve command.

Post decompression is complete when the injection cylinder position is equal to or greater than the post decompress position parameter. When post-decompress position is achieved the card sets the valve outputs to zero and signals to the machine sequential logic controller.

Injection Configuration Options

The DPQ can be applied in one of two injection configurations that depend on the hydraulic system.

1. Preferred configuration: closed loop velocity profile and pressure control using one proportional injection valve and one analog valve output. This type of system will control the injection velocity profile, pressure profile, back pressure, and screw decompress from a single high response proportional directional control valve. The available dynamic response using this type of system is much better than systems that use separate valves for flow and pressure control, which means that the closed loop tuning can be adjusted for faster and more precise control.

2. Closed loop velocity profile, and either closed or open loop pressure control using one proportional directional or flow control valve for the velocity profile and one proportional pressure control valve for injection pressure control. There are two analog valve outputs available for this configuration. This configuration does not require as high dynamic response from the proportional flow control valve as the single valve configuration. Overall system control will not be as dynamic or repeatable due to limitations of separating flow and pressure functions into multiple valves, and inherent dynamic limitations of proportional pressure control valves.

Additionally, the DPQ may be configured so that the second valve output is controlled directly by a machine logic controller instead of the internal pressure profile.

Functional description (continued)

Ejector Control

Two segment extend profile

The DPQ includes two forward velocity segments and acceleration ramp adjustment to protect the molded part. One or both extend segments may be used.

Automatic retract

The DPQ can be triggered to automatically retract the ejector cylinder(s) after reaching the extend position. If the retract trigger is not raised at prior to the ejector cylinder reaching the extend position then the ejector will stop. Retract may then be triggered by the machine controller at the appropriate time.

Tip Stroke

The DPQ can store two retract positions, and triggered to retract to either one. This way a short extend and retract sequence may be triggered to assure that a part has been released.

Multi Stroke

A trigger can be set that will cause the DPQ to continuously cycle the ejector to either the tip stroke position or full retract position. This allows one trigger to extend and retract the ejector multiple times as quickly as possible. The DPQ will complete the current cycle and then stop once the multi stroke trigger is lowered.

Ejector Configuration Options

Three possible configurations for the ejector profile control allow flexibility in the hydraulic circuit design.

The DPQ can be configured to use the injection flow control valve or a separate proportional control valve for the ejector profile. If a dedicated ejector proportional directional valve is connected to the third valve output, then the VT-HACD-DPQ-2X may also be configured for closed loop ejector control. Alternatively, the third valve output may be configured to be controlled directly by the machine logic controller instead of the ejector profile.

Applications

The DPQ is configured to control injection molding type applications and all parameters are labeled to be recognizable in injection molding applications. There are, however, many other applications that could benefit from the quality of control afforded by the DPQ.

Typical applications include:

- Transfer molding
- Extrusion
- Broaching
- Rubber molding
- Accumulator head blow molding

Front Panel Operation

The front display is used in conjunction with the 4 push buttons to display and change operator parameters.

Access is given to the following operator parameters:

- Mold fill profile
- Transfer parameters
- Hold pressure profile
- Recovery profile
- Decompress parameters

For safety reasons, set-up and configuration parameters are not accessible through the front panel.

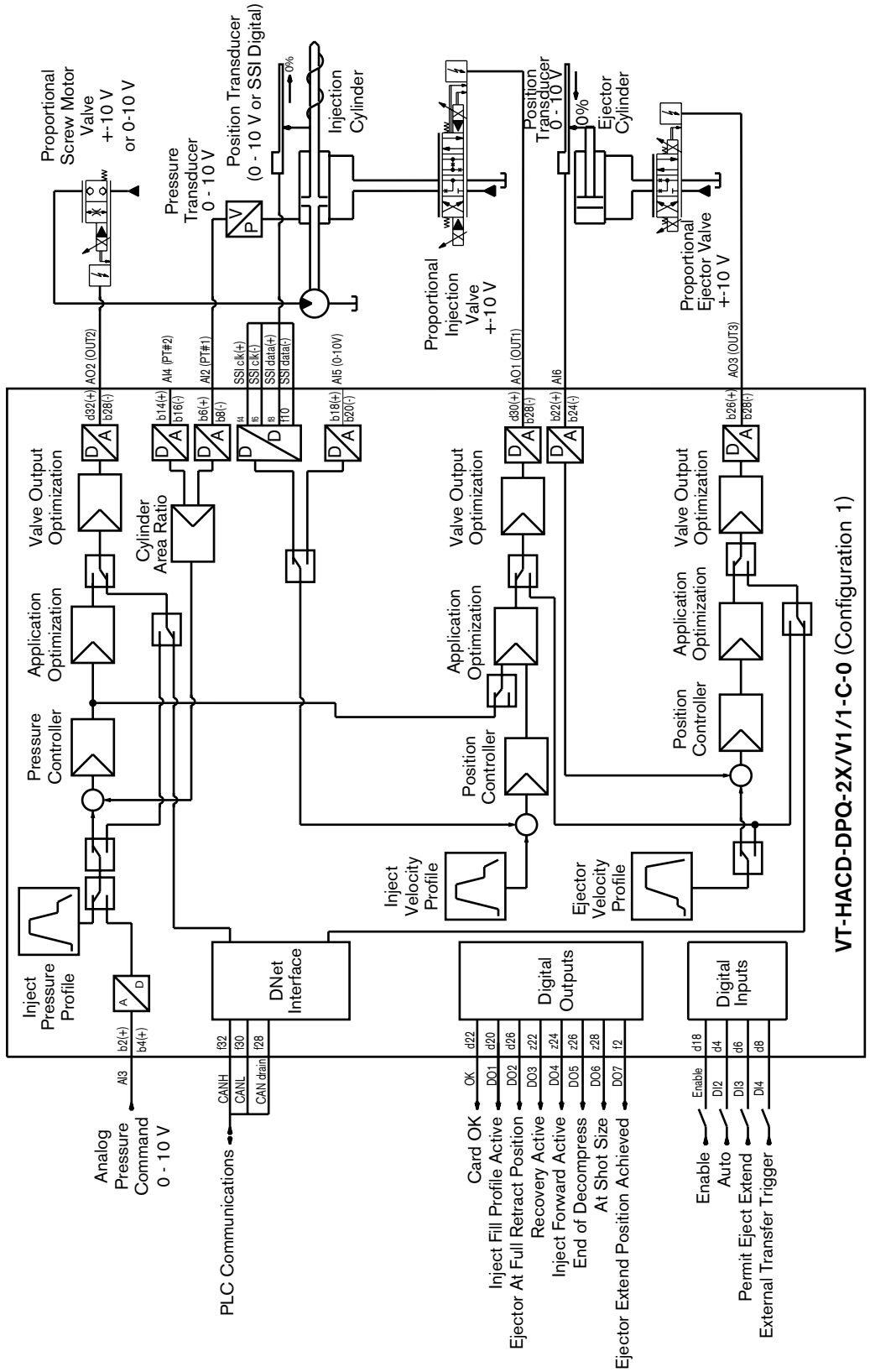
Fault messages will be displayed if they occur.

PC Program BODAC

The PC program BODAC makes it possible to configure, parameterize and perform diagnostic functions on the VT-DPQ-1-2X via a serial interface (RS232).

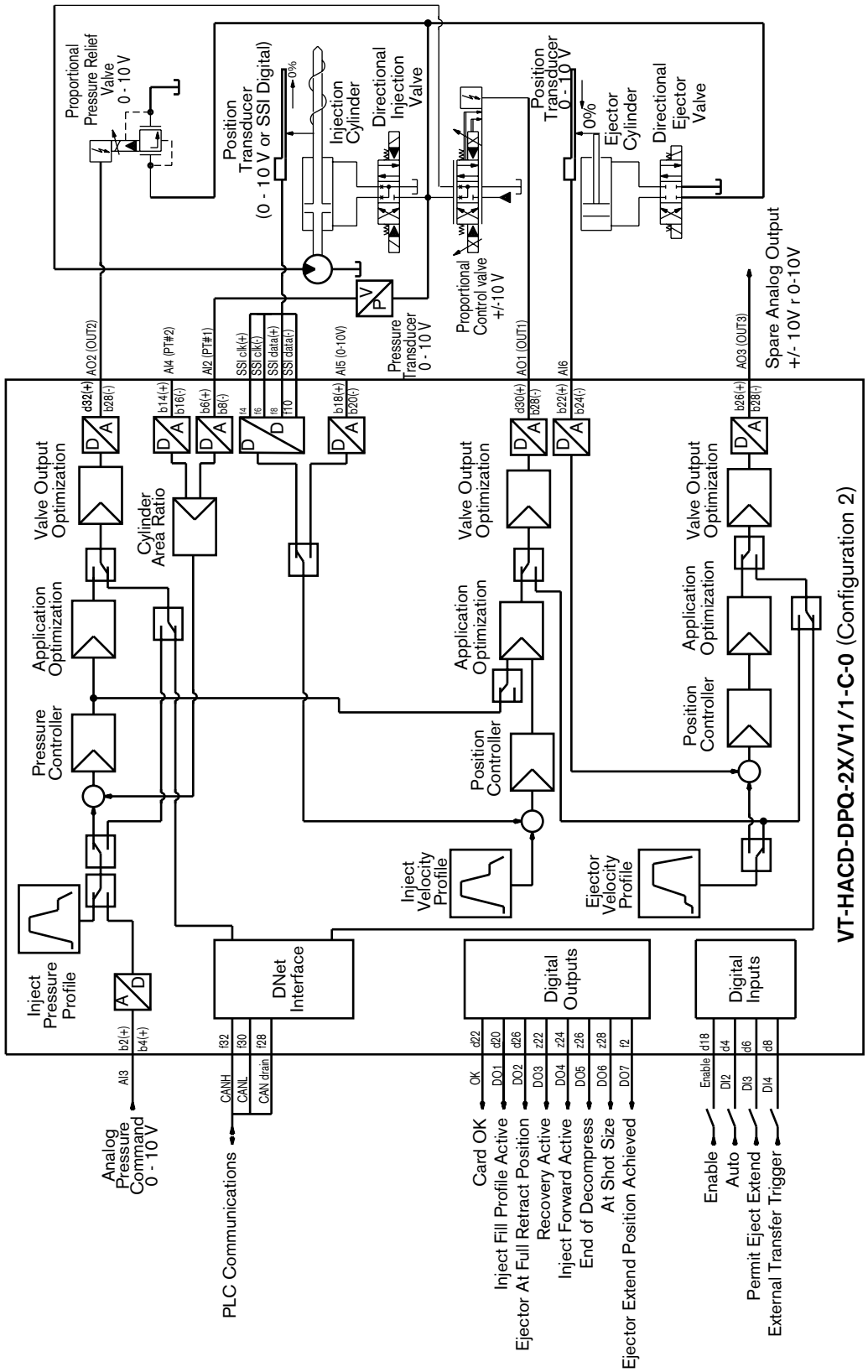
CD ordering code: SYS-HACD-BODAC-01 or download via the internet, address www.boschrexroth.com (Navigation: Industrial Hydraulics -> Products and Solutions -> Product Overview -> Digital open and closed loop controls -> HACD -> PC program BODAC

Block circuit diagram: VT-HACD-DPQ-2X (Configuration 1)



Typical injection circuit using one proportional control valve, one proportional ejector valve and the PLC to control output AO2 (Out2) directly to a proportional screw motor valve.

Block circuit diagram: VT-HACD-DPQ-2X (Configuration 2)



Injection circuit using one proportional flow control valve for injection velocity, ejector velocity and screw motor speed in combination with a separate proportional pressure control valve. Output AO3 (Out3) can be configured so the PLC directly controls the analog output for other functions that can be unrelated to the injection control.

Technical data (for applications outside these parameters, please consult us!)

Operating voltage	U_B	24 VDC
Functional range:		
- Upper limiting value	$U_B(t)_{max}$	35 V
- Lower limiting value	$U_B(t)min$	21 V
Current consumption	I_{max}	150 mA
Fuse	I_s	4 AT
Digital inputs Voltage	*Log 0(low)*	0 to 5V
	Log 1 (high)	15V to U_B
Digital outputs Voltage	*Log 0(low)*	0 to 5V
	Log 1 (high)	15V to U_B
		I_{max}= 30 mA
Analog inputs		
Range	*U*	0 to 10V or ± 10V (configurable)
Input resistance	R_e	200 kΩ, > 10MΩ for AI1
Resolution		5 mV for range ± 10V
		2.5 mV for ranges 0…10V
Non linearity		< 10mV
Analog outputs		
AO1		
Output voltage	U	± 10V
Output current	I_{max}	20 mA
Load	R_{min}	500 Ω
Resolution		1.25 mV (14bit)
Residual ripple		± 15 mV (without noise)
AO2+AO3		
Output voltage	U	± 10V
Output current	I_{max}	10 mA
Load	R_{min}	1 kΩ
Resolution		10 mV (11bit)
Residual ripple		± 25 mV (without noise)
Sampling interval	*T*	2 ms
Serial interface		RS232 (front plate), D-sub socket
Connection type		64 pin blade connector, DIN 41 612, form G
Card dimensions		Eurocard 100 x 160 mm, DIN 41 494
Front plate dimensions		
- Height		3 U (128.4 mm)
- Width soldering side		1 HP (5.08 mm)
- Width component side		7 HP
Permissible operating temperature range	ϑ	0 to 122 °F (0 to 50 °C)
Storage temperature range	ϑ	4 to 158 °F (-20 to +70 °C)
Weight	*m*	0.2 kg

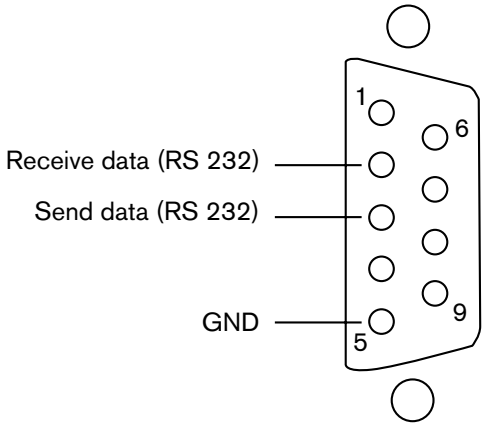
Note: For details regarding the **environmental simulation test** covering EMC (electromagnetic compatibility), climate and mechanical loading see RE 30 143-U (declaration regarding environmental compatibility)

Connection diagram connector

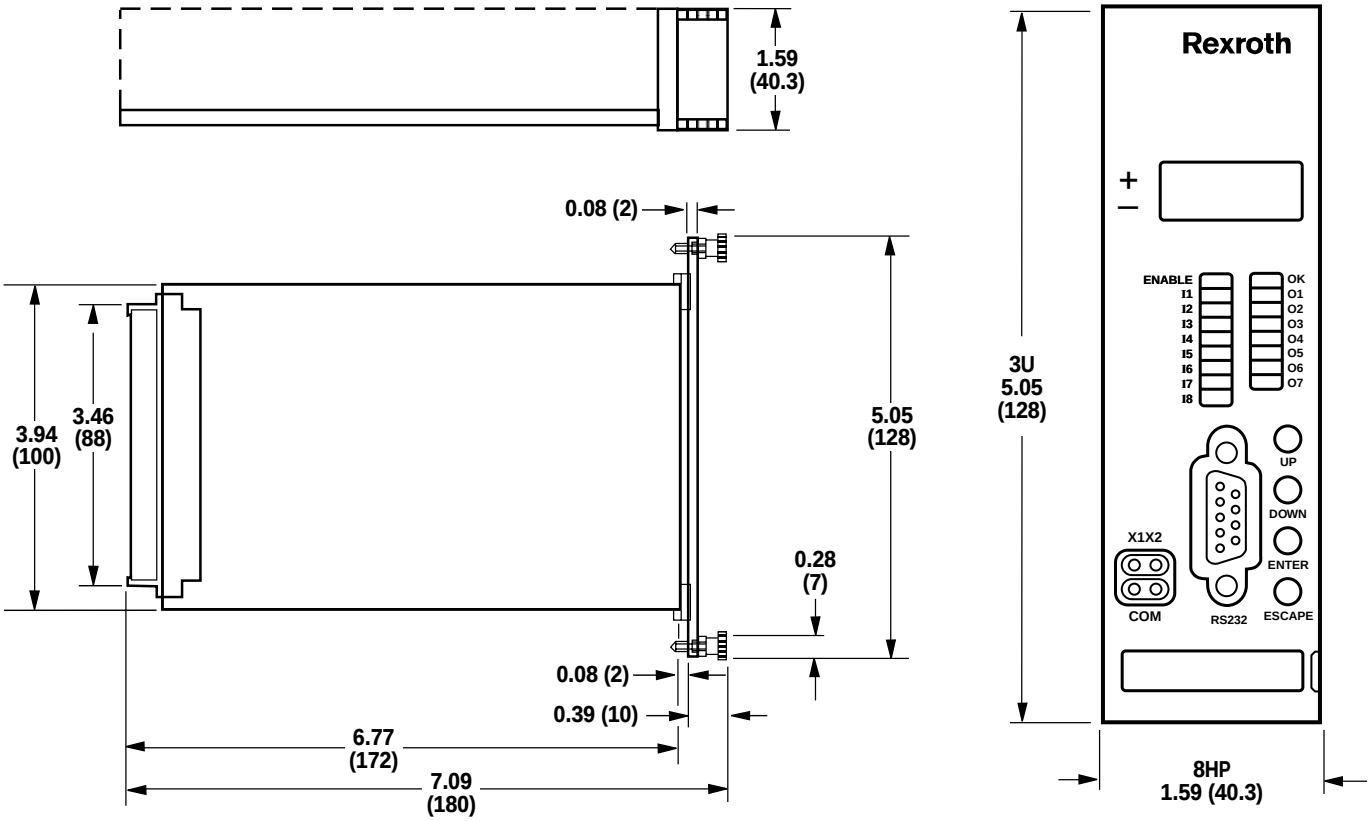
Pin	Row z	Row b	Row d	Row f
2	n.c.	AI3+: Pressure Mold Cavity	DI1: (Spare)	DO7: Ejector Extend Position Achieved
4	n.c.	AI3-: Pressure Mold Cavity	DI2: Auto (RUN)	SSI clock +: Inject cylinder FB
6	n.c.	AI2+: Pressure FB#1	DI3: Ejector Extend Permit	SSI clock -: Inject cylinder FB
8	n.c.	AI2-: Pressure FB#1	DI4: External transfer Trigger (option)	SSI data +: Inject cylinder FB
10	Shield	AI1+: Valve#1 spool position[1)]	DI5: (Spare)	SSI data -: Inject cylinder FB
12	n.c.	AI1-: Valve#1 spool position	DI6: (Spare)	AI8+: Clamp pressure Valve CMD#2
14	n.c.	AI4+: Pressure FB#2	DI7: (Spare)	AI8-: Clamp pressure Valve CMD#2
16	n.c.	AI4-: Pressure FB#2	n.c.	n.c.
18	n.c.	AI5+: Inject cyl. FB (optional)	Enable	n.c.
20	n.c.	AI5-: Inject cyl. FB (optional)	DO1: Inject Fill Profile Active	n.c.
22	DO3: Recovery Active	AI6+:Ejector cylinder FB	Card OK	n.c.
24	DO4: Inject Forward Active	AI6-: Ejector cylinder FB	n.c.	n.c.
26	DO5: End of Decompress	AO3: Valve CMD Ejector Profile	DO2: Ejector at Full Retract Pos.	n.c.
28	DO6: At Shot Size	Analog GND	n.c.	CAN drain
30	U_B: +24V	- 10 V	AO1: Valve CMD Inject Profile	CANL
32	L0: 0V	+ 10 V	AO2: Valve CMD Pressure Profile	CANH

[1)] This input has an input resistance of R_e > 10 MΩ (For monitoring purposes only)
n.c. … is not connected

Connection diagram of the D-sub socket on the front plate



Unit dimensions: dimensions in inches (millimeters)



Engineering / maintenance guidelines / additional functions

- Use low-capacitance cables. Make cable connections without intermediate connections whenever possible.
- Control electronics should be isolated from electromagnetic noise sources (e.g. Variable frequency drives).
- Power wiring should not be routed in the vicinity of control electronics.
- Power wiring should not be routed in the vicinity of control wiring or cables.
- Route sensor lines separately.
- Maintain a distance of at least 1 meter from antenna lines, RF devices and radio equipment.
- When using differential inputs switch both inputs on and off at the same time.
- When switching signal inputs, use dry circuit rated relays with gold-plated contacts (low voltages, low currents)
- Always shield all analog signal lines. Connect shields at the card end only, connecting to the “Shield” terminal, and leave the other end open to prevent ground loops.
- Connect to an appropriate system ground using stranded copper wire (min 2.5mm2 / 12 AWG)!
The system ground is an essential component of the EMC protection for the controller card. The ground provides a path for noise that could otherwise enter the controller card through the signal and power supply lines. Noise is bypassed only if the system ground does not couple noise into the controller card. Rexroth also recommends shielding solenoid wiring.
- Do not use logical signals from the controller card (e.g. “OK” signal) for switching machine safety circuits
(see European Norm “Safety Requirements for Fluid Power Systems and Components” EN982:1996).

Notes

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