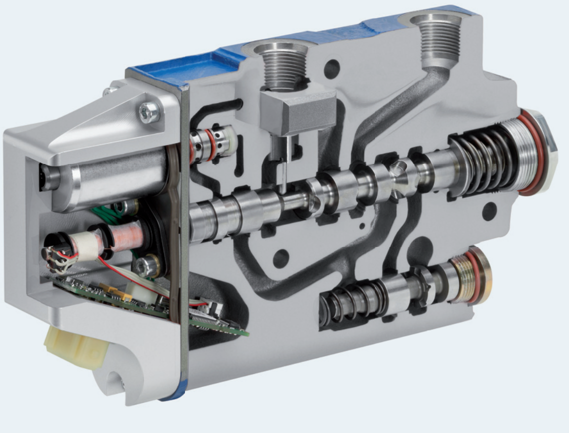
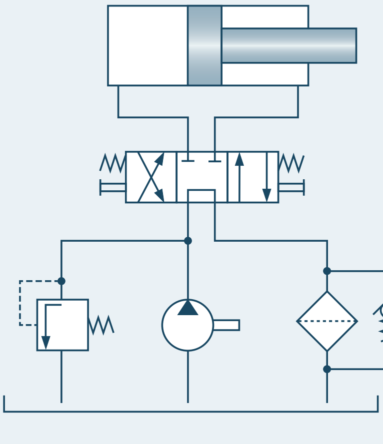
The Drive & Control Company

Rexroth
Bosch Group

Knowledge in Detail

Hydraulics in Tractors





Contents

5.3.2 SB23-EHS1 directional valves

The directional valve SB23-EHS1 is a further development of the SB23-EHS, featuring the same essential performance data.

Figure 5.35 shows a sectional view of the valve slice. The difference is that the flanged EHS actuator unit has been replaced by an integrated pilot system.

The 4/3-way pilot valve is integrated in the valve housing and instead of a separate stroking cylinder, the end faces of the piston spool are used as its control as is common with pilot operated valves. Mechanical control is no longer available. Emergency manual actuation can be fitted on request.

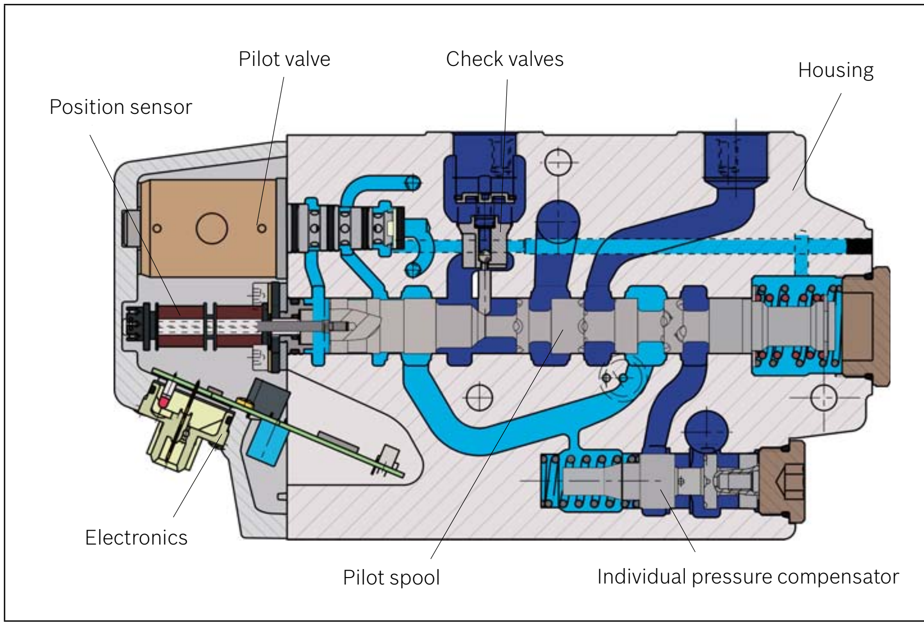


Fig. 5.35: Sectional view of a Rexroth SB23-EHS1 valve slice

5.3.3 SB33-EHS2 directional valves

Figure 5.36 shows a sectional view of a valve slice SB23-EHS1 and a valve block of the series SB33-EHS2 with four slices.

In 2006, Bosch Rexroth realized a new basic valve concept whose performance data can also satisfy future requirements. The most important features are:

- Increased flow range
- Lower flow resistance
- Load-compensated input and output flows
- Hydraulically controlled check valves
- Integrated pressure sensors
- Higher dynamics
- Suitable for use as control valve for EHC hitch control

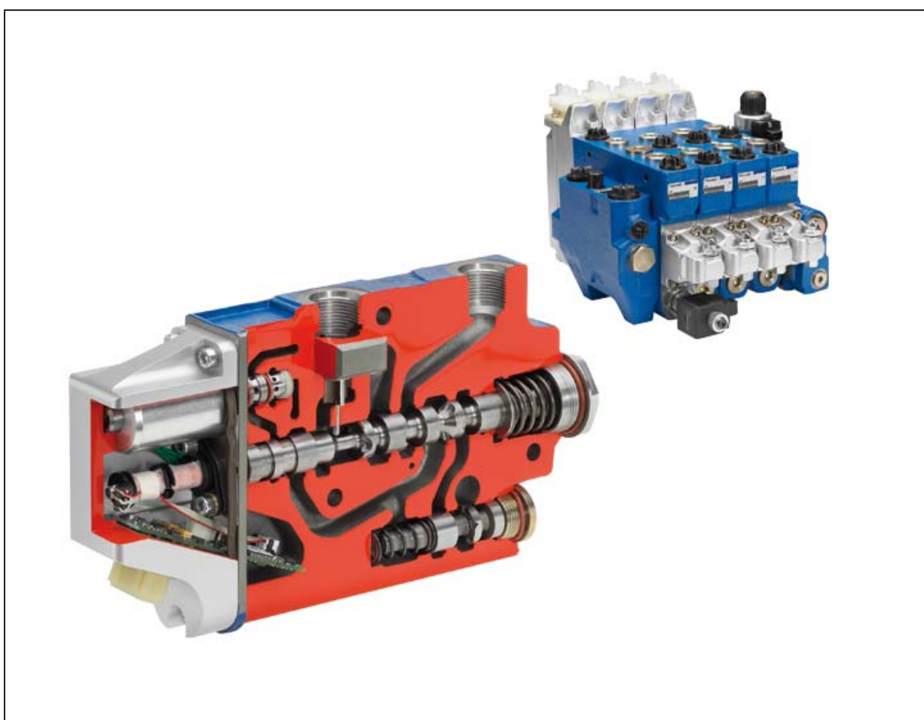


Fig. 5.36: Rexroth SB33-EHS2 valve block and sectional view of a SB23-EHS1 valve slices

Like on the EHS1, the main spool is controlled via a 4/3-pilot valve, which is integrated in the valve slice and uses the end faces of the main spool for its control.

The hydraulically controlled check valves in both of the consumer ports are new. They have the function of hydraulically unlockable check valves, working as load compensating pressure compensators, like lowering valves, for lowering or driving loads.

Another new feature is that the valve can be optionally equipped with up to three pressure sensors, which, as shown in Figure 5.37, can be assigned to five different measuring points.

The maximum intake flow can amount to 170 l/min and in the return flow channels 250 l/min. The flow resistances and thus the power dissipation compared to the SB23-EHS1 are reduced at the same time.

The electronically controllable valves are increasingly used for automatic control of working processes. The dynamic behavior has therefore been reduced from 70 ms to 50 ms for a full stroke from the center position.

At the same time the resolution of the flow curve in the fine control range has been improved to approx. 0.2 l/min. The float position of the valves is often used for light implements which lie on the ground and are to follow the ground profile.

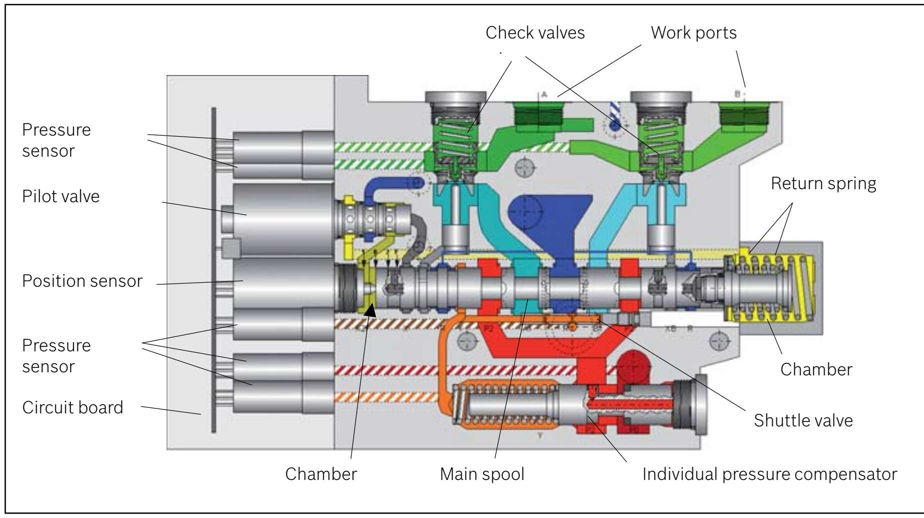


Fig. 5.37: Design of a Rexroth SB33-EHS2 directional valve

This requires minimal flow resistance in the connected cylinder lines. This is achieved through large flow cross-sections of the check valves, which are hydraulically fully opened.

As described for EHS valves, the operator can conveniently change the flow characteristics and the time response of the valves electronically and adapt to the relative work task. The valves are parameterized via the CAN interface. With the aid of software tools, the tractor manufacturer can develop and test an optimal operating concept for the machine. The tractor driver is offered an operating concept that does not place high demands and that allows to adapt the controls to the special work tasks of the attached machines in a simple manner.

A diagnosis memory is integrated in the valve electronics. The operating conditions are saved here and can be read and evaluated with an easy to operate software tool.

5.3.3.1 Valve operating positions

Position “0” – neutral

The valve's functional range is comprehensive and complex. The functions of the individual components for the four valve spool positions are described below. The transitions between the positions are stepless, each main spool position is set in a position controlled manner, relevant to the setpoint value.

Figure 5.38 shows the valve in neutral position, with a signal-free pilot valve. The pressure chambers at the end of the main spool are unloaded via the pilot valve to the pilot return line Rx, and the main spool is centered in neutral position by the return spring, see Figure 5.37. The spool for opening the check valves and the spring chamber in the pressure compensator are unloaded to the return line R.

Position "1" – Operating the cylinder via port B

In position "1" the centering-spring chamber at the spool end to the right is pressurized via the pilot valve. The pressure chamber at the left side of the main spool is unloaded to the pilot flow return line. Against the return spring force the main spool is shifted to the left.

At the main spool, the control edges P2-B and A-R are opened, port B is connected to the pump flow and port A to the return flow.

The spool for opening the check valve in A is connected to the pilot pressure X and pushed open hydraulically, so that the return oil flow from port A can flow unrestricted to the return line

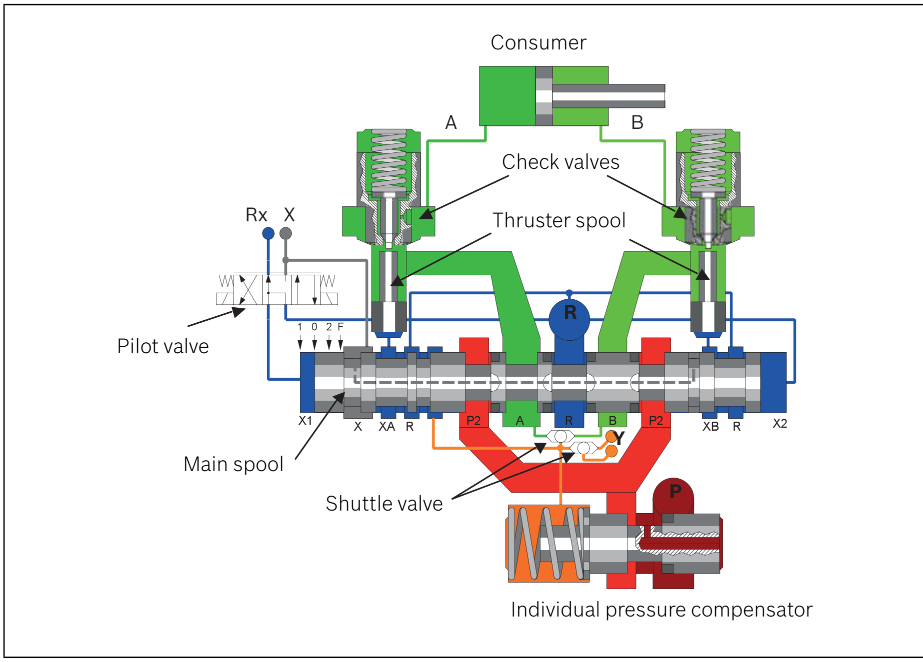


Fig. 5.38: Neutral position of the Rexroth SB33-EHS2 valve

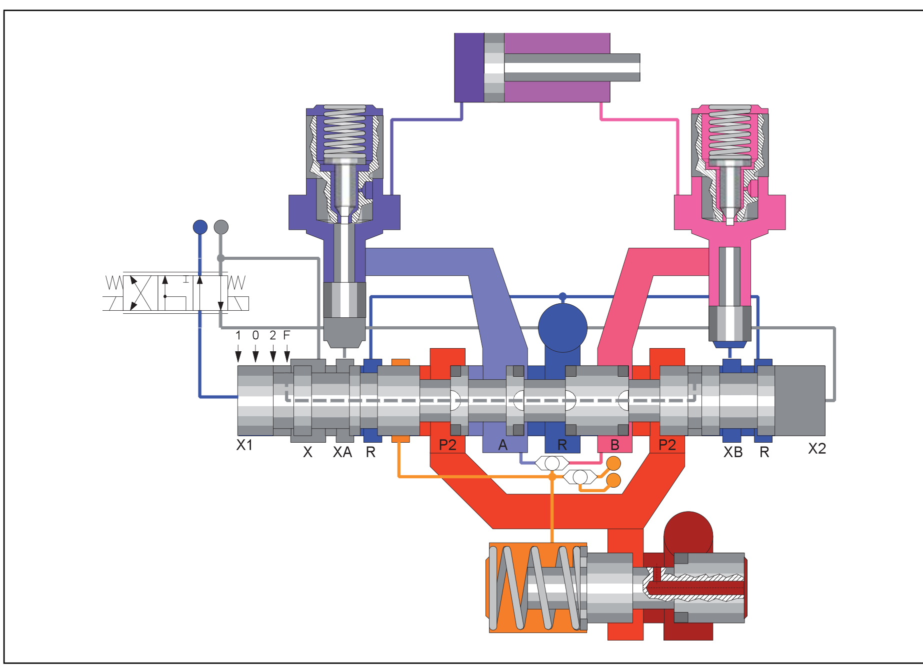


Fig. 5.39: Rexroth SB33-EHS2 valve in position"1" – cylinder drive via port B

The check valve B is not piloted, as it functions as a check valve and opens itself through the flow to the load. The connection between the spring chamber of the pressure compensator and the return line is closed and connected via a shuttle valve to the load pressure in the B-channel.

Position "2" – Operating the cylinder via port A

In position "2", see Figure 5.40, the pressure chamber at the left spool side is pressurized via the pilot valve and the spring cap chamber is unloaded to the pilot oil return line. Against the return spring force the main spool is shifted to the right. The further control operations take place in a similar way as in position 1.

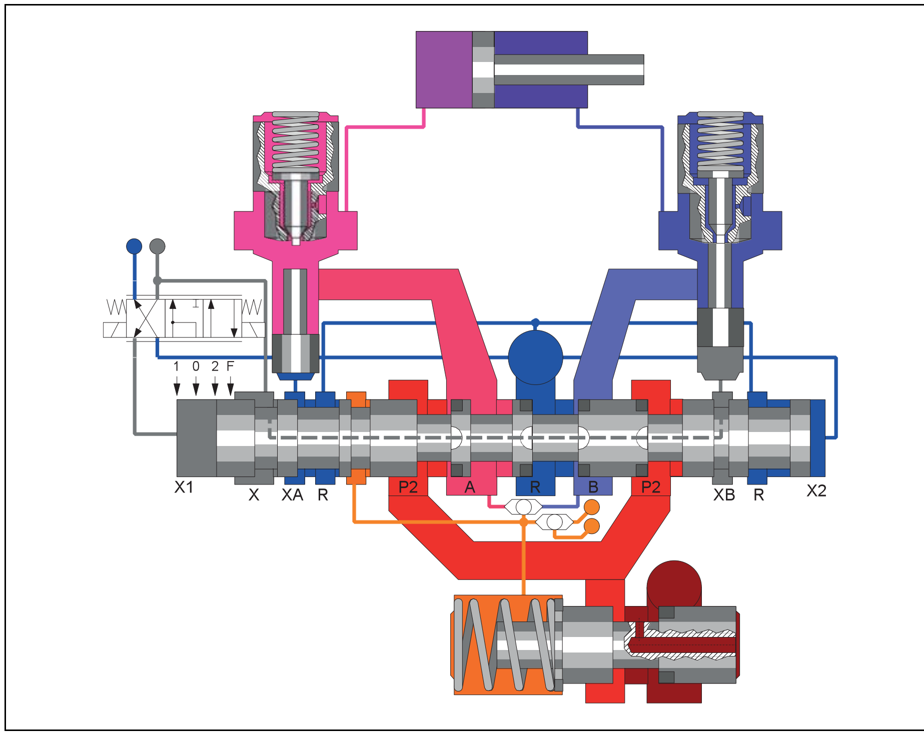


Fig. 5.40: Rexroth SB33-EHS2 valve in position"2" – cylinder drive via port A

Position "F" (float)

In the position "F" (float), see Figure 5.41, the main spool is shifted beyond position 2 against the stroke stop in the spring cap.

Both service line ports A and B are connected to the return line (A-R, B-R) and therefore also with each other. In this position, the connections from the pump to the load are closed and the spring chamber in the pressure compensator is unloaded to the return line R.

The control chambers of both check valve pilot spools are connected to the pilot pressure X and are hydraulically pushed open.

Both cylinder ports are therefore connected with each other and a connected cylinder can move freely.

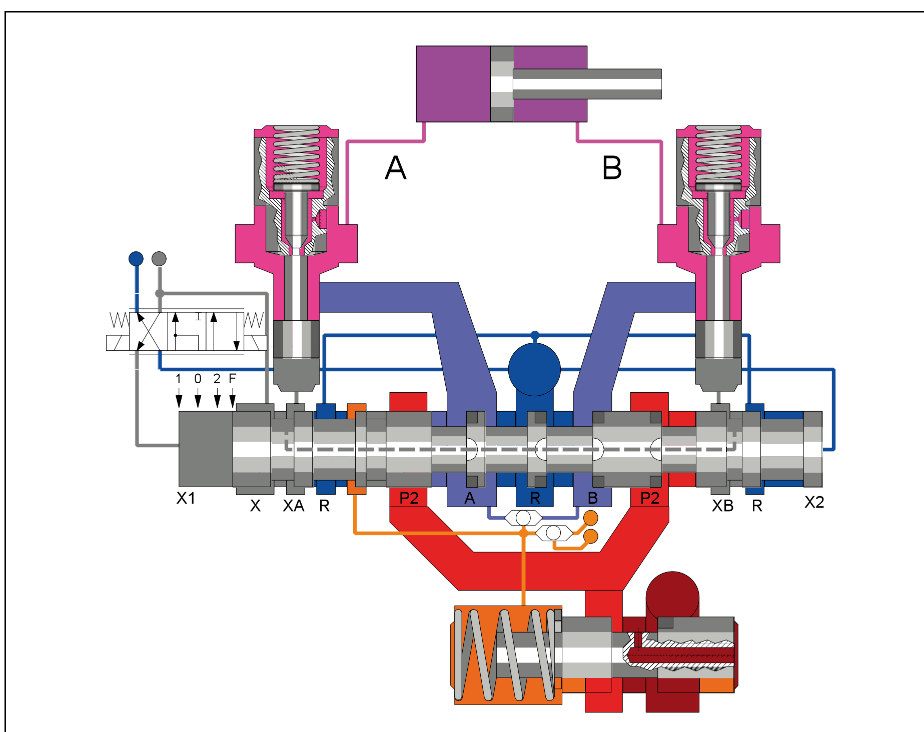


Fig. 5.41: Rexroth SB33-EHS2 valve in position "F" (float)

5.3.3.2 Special valve functions

Load compensated return flow with a pulling load

With the throttle control systems commonly used to date and operation with pulling loads, a compromise between the controllability of heavy and light loads is always necessary.

The resulting speeds are always too high with heavy loads and too low with light loads.

In the case of double-action cylinders and heavy loads, the oil flow to the inlet side is too low, resulting in a cavity which needs refilling upon switching to the other direction. With low load pressures on the other hand, the pump must even generate pressure when lowering the load, which results in energy losses. These problems are prevented with the new control of the check valves.

These check valves control the oil flow from the cylinder to the return line, in principle like the individual pressure compensators control the flow from pump to valve. The cylinder speed is now independent of the load pressure. Through the new "active filling" function, the pressure in the flow to the cylinder remains at a constant low level at high or low load pressure, without a vacuum or pressure increase.

A special LS circuit concept with an AB shuttle valve automatically detects an insufficient filling of the cylinder inlet side and controls the pump or pressure compensator in such a manner that partial vacuum is prevented.

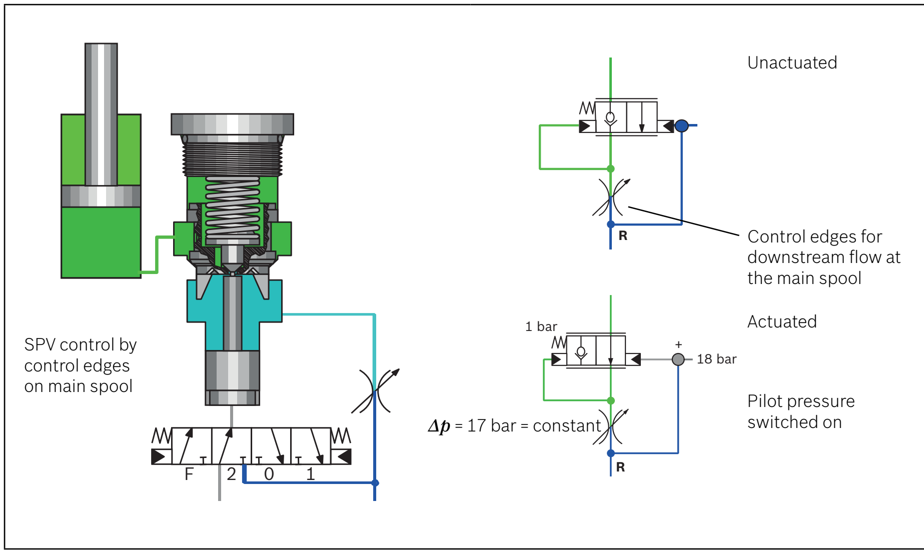


Fig. 5.42: Function of the check valves with load compensation for the return flow

With these features, the valve can control loads going from positive to negative pressures without delay.

This is a necessary precondition for a double-action EHC hitch function, which will be dealt with in Chapter 6 "Electronic controllers and bus systems".

Figure 5.42 shows the working principle of the check valve. The pilot pressure is used to keep the pressure drop and thus the flow at the return flow control edges in the valve constant, regardless of the load pressure.

As the schematic in Figure 5.42 shows, the check valve controls the pressure drop at the return flow edge of the main spool to 17 bar, when the pilot pressure is 18 bar and the equivalent check valve spring pressure amounts to 1 bar. Since the pilot pressure is switched onto the return line, a tuning with the return line pressure of the respective machine is necessary.

Integrated pressure sensors

A peculiarity of the SB33-EHS2 valve are the pressure sensors, which can be mounted in the electronic unit in the valve. These sensors enable a lot of new, especially automatic functions.

A maximum of three pressure sensors can alternatively measure the pump pressure, the LS pressure at the valve outlet and in the valve, and the load pressures in the service line ports.

Figure 5.43 shows the block circuit diagram of the integrated electronics of the SB33-EHS2 valve.

The pressure signals can be processed internally in the valve or externally, since they are available in the CAN bus. Typical internal valve functions are a freely programmable kickout or the automatic pressure-dependent reversing of a drive function.

A typical example of this is the turning of a plow at the end of the field, in which the cylinder is reversed in dead center. To complete this function the relevant SB33-EHS2 valve only has to be actuated once. The next sequence follows automatically, since the pressure-controlled valve reverses the turning cylinder automatically in dead center.

Upon reaching the stop, the kickout function switches the valve back into neutral position, see Figure 5.44.

Typical functions with external processing of the pressure signals are pressure dependent controls and pressure controls as well as system monitoring and diagnostics.

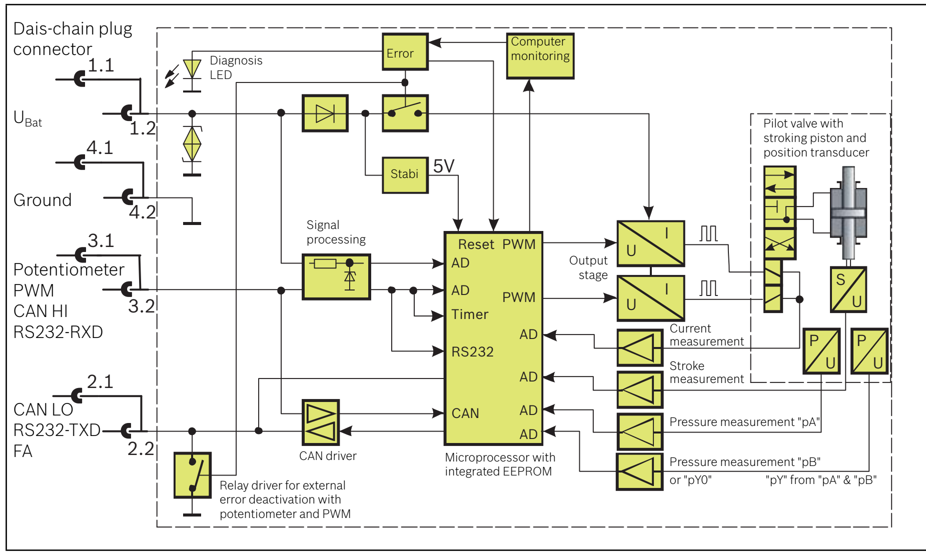


Fig. 5.43: Block circuit diagram of the SB33-EHS2 valve electronics with two pressure sensors

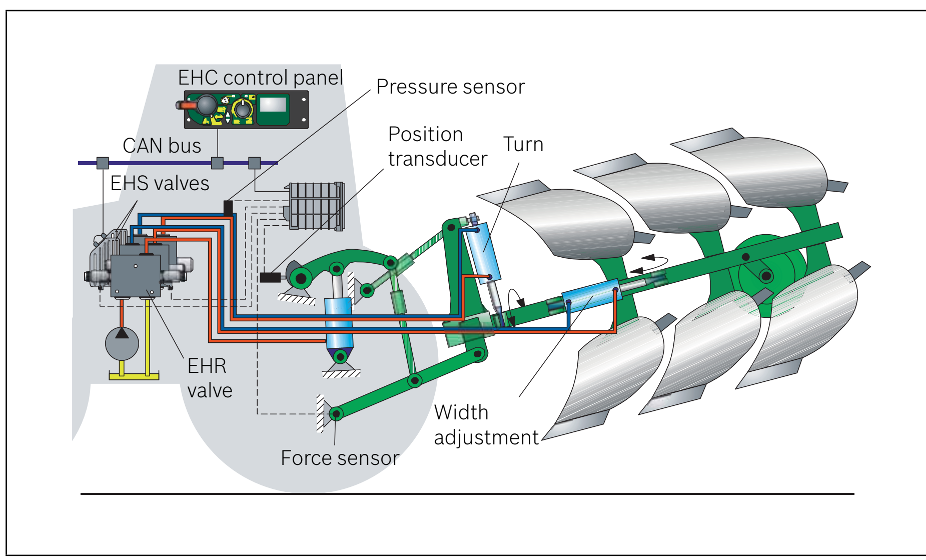


Fig. 5.44: Automatic reversing function of an alternating plow

5.4 Joysticks – mechanical-electronic control levers

For electronic directional valves, which are manually controlled, a special control lever, a so-called "joystick" is needed. When actuating the lever, such joysticks transmit a DC-voltage, a PWM or a CAN signal via cable to the directional valve, causing the spool position to be adjusted proportionally to the deflection angle of the joystick handle. This is similar to the mechanical actuation.

Their design configuration is based on mechanical-hydraulic devices, as have been standard for years in large construction machines for the control of valves in the large power range. Figure 5.45 shows both of the actual series THE and EJ. The THE series was designed for construction machinery, especially excavators, where they are used to control the main working functions. Units of the EJ series are smaller and were designed for use in tractors and fork lift trucks. Mounting dimensions and electrical connections are identical however.

Figure 5.46 shows the design layout of an EJ joystick, comprising the following components:

1 Operator handle
2 Mounting flange
3 Housing for sensors and electronic controller
4 Hall sensor for angular measurement
5 Spring cup
6 Rubber bellow
7 Solenoid
8 Return spring
9 Connecting lever

Fig. 5.45: Rexroth-joystick series THE and EJ

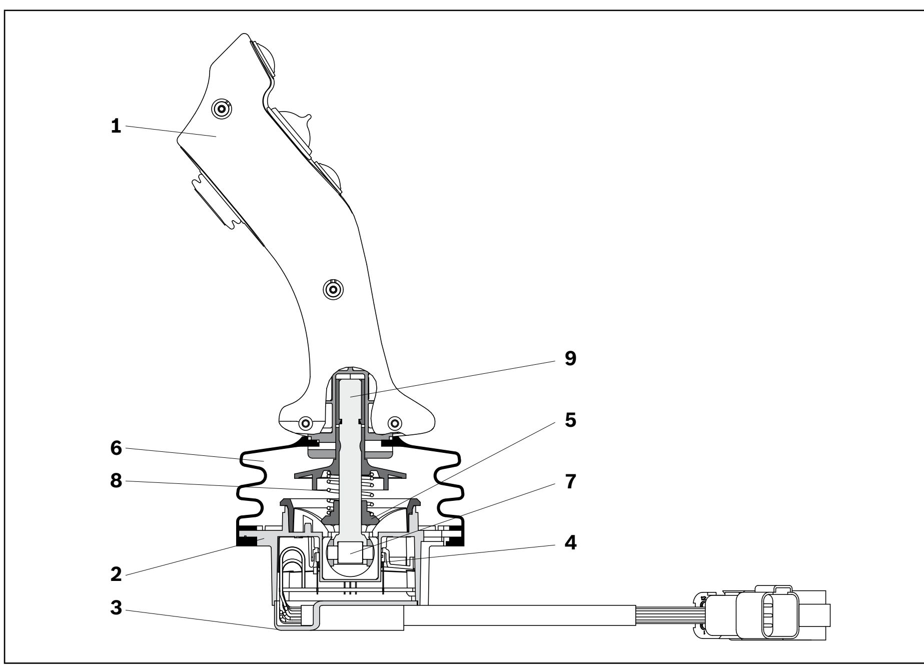


Fig. 5.46: Design layout of a joystick

The operating handle (1) is via a lever (9) connected to the solenoid (7), which is mounted in a ball joint which can be rotated in all directions. Shifting the lever in a main axial direction – in the illustration to the left or to the right – causes the solenoid in the ball joint to rotate and the angle of rotation is measured contact-free and free of wear with a Hall sensor. It is possible to arrange two solenoids at the lever (9) in the area of the ball joint, of which the main directions of actuation are 90° offset against each other. In this manner, two valve segments can be operated with one lever – also simultaneously – see Figure 5.47.

The spring cup (5) is supported on a trumpet-bell-like sleeve so that the spring (8) provides a reset force to neutral position in any direction of deflection.

Mechanical pressure points can also be realized if desired, enabling a haptic detection of certain positions by the operator e.g. "float". The electronics integrated in the housing generate an output voltage dependent on the joystick lever deflection angle. With DC voltage systems, this enables a direct control of valves. PWM or CAN BUS control signals must be generated by the electronics installed, see Figure 5.47.

In tractors with smaller volumes, the EHS valves are controlled with pulse width modulation (PWM). In tractors with larger volumes, the control is usually realized by CAN BUS.

Figure 5.48 shows the input and output signals of the integrated electronic controller of an EJ joystick with PWM control.

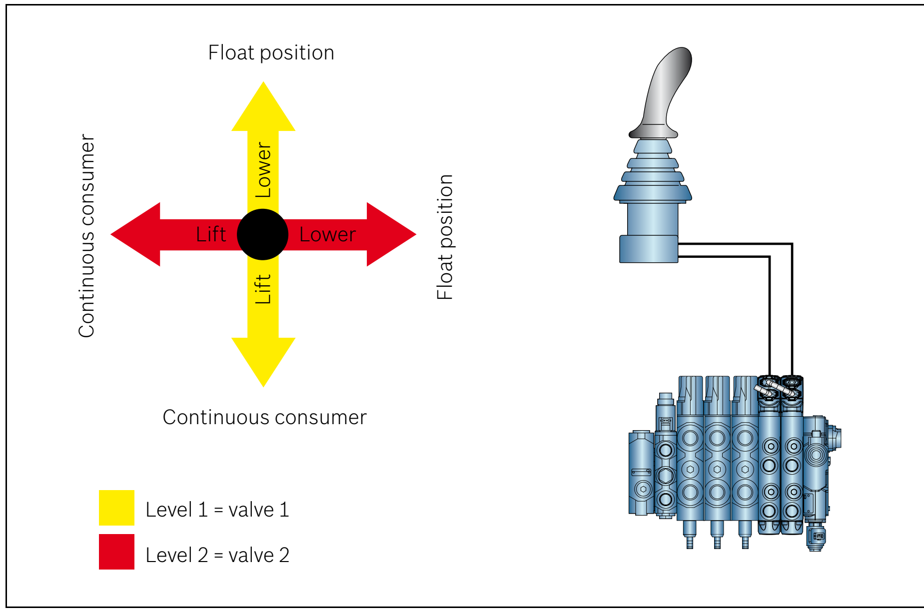


Fig. 5.47: Functions of a 2-axis joystick

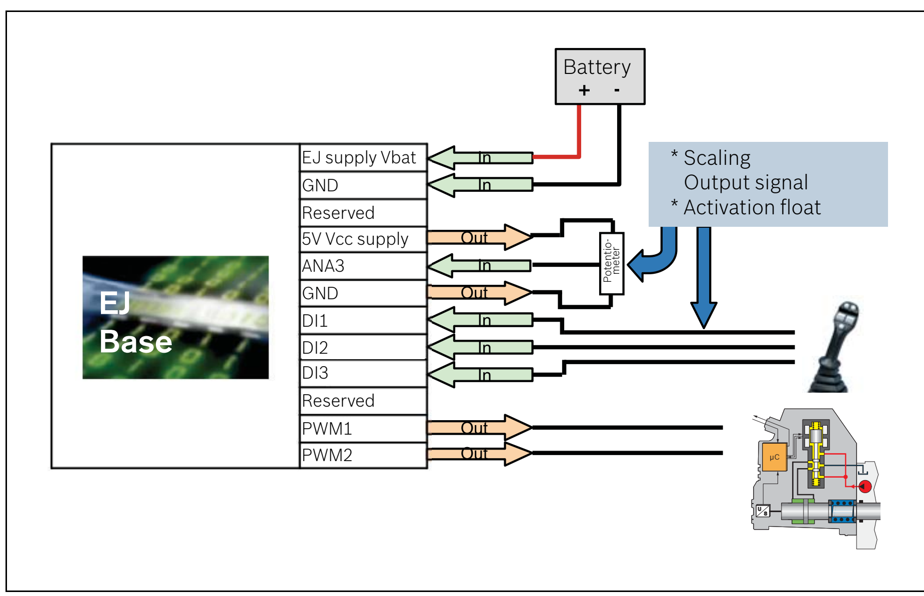


Fig. 5.48: Input and output signals of the electronics of a Rexroth EJ joystick with PWM signal

5.5 Priority valves

The function of priority valves is based on the principle of a 3-way flow control valve, see Figure 5.49.

A 3-way flow controller is realized by switching in parallel a variable metering orifice (1) with a pressure compensator (2), controlling a valve spool. The controlled flow through the metering orifice is independent of the load pressure p_2. The pressure p_1 upstream of the metering orifice is connected to the piston side and the pressure p_2 downstream of the metering orifice to the spring side of the pressure compensator spool. If port 1 carries an oil flow larger than that desired, the pressure compensator spool will be shifted to the right until the forces through the pressure differential $\Delta p = p_1 - p_2$ at the piston are equal to the spring force.

This condition is necessarily reached and the metering orifice with a cross section A then carries a controlled flow $q_v \sim A \times \sqrt{\Delta p}$ to port 2. The surplus rest flow goes to port 3. Port 2 thus always has priority over port 3. Priority valves work on the same principle.

However, the schematic illustrated in Figure 5.49 with one control spool orifice only works if the pressure at port 3 is lower than at port 2, which is not the case with priority valves. Depending on the hydraulic system and on customer requirements, different design variants of priority valves have come into being.

Figure 5.50 shows a priority valve in sandwich plate design, which can be integrated in valve blocks together with SB23 directional valves.

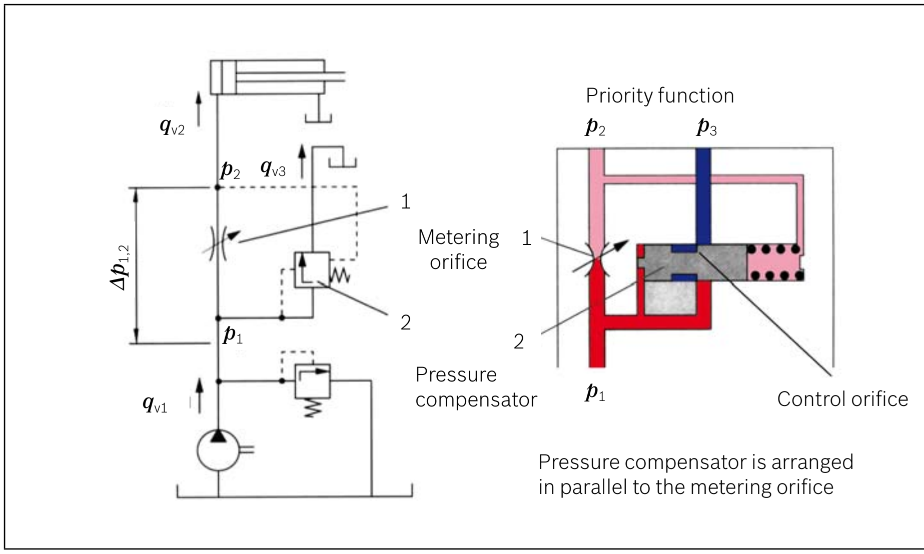


Fig. 5.49: Design and schematic of a 3-way flow controller

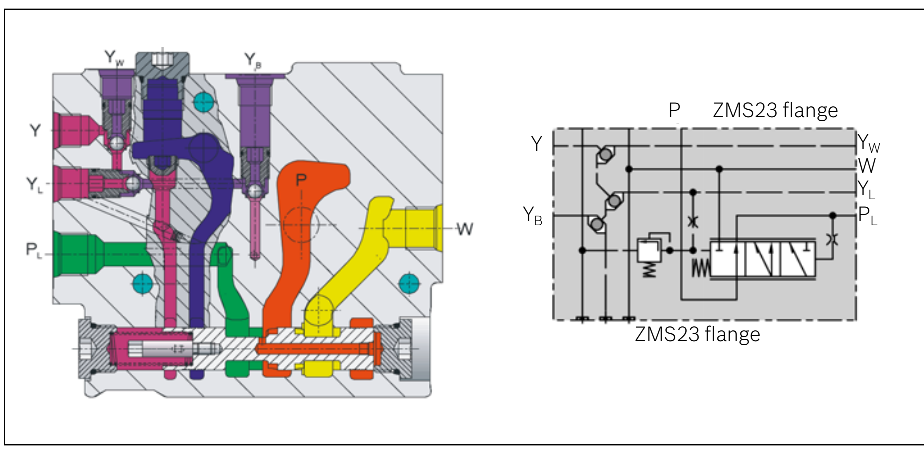


Fig. 5.50: Rexroth priority valve in sandwich plate design with SB23 bolt hole pattern

In the sectional view and in the schematic illustrated in Figure 5.50, the spool functions as a pressure compensator. P_L is the connection to the prioritized consumer and Y_L the load feedback, picked up downstream of its metering orifice. W is the continuing path to the consumers without priority.

The schematic in Figure 5.50 shows, that the pump flow is also led to the pressure compensator spool. This spool has two sides with control edges, which can be activated as control orifices depending on the pressure conditions. If the pressure in the continuing path W is higher than in the prioritized function the control edge from red to green is active, otherwise the one from red to yellow. However, the priority valve spool is controlled like the one in the 3-way flow controller and is arranged parallel to the metering orifice. The load pressure Y_L downstream of the metering orifice of the prioritized consumer is connected to the spring side and the upstream pressure to the piston side of the spool.

Multiple priority stages can be combined into one unit, which is the case with valves of the LT series for a central hydraulic system with a variable pump, see Figure 5.51.

Bosch Rexroth has different design versions of priority valves for integrating directional valve series into valve blocks, see Table 5.2.

Special solutions for steering systems and integrated priority valves for trailer brake valves BV are dealt with in the relevant chapters.

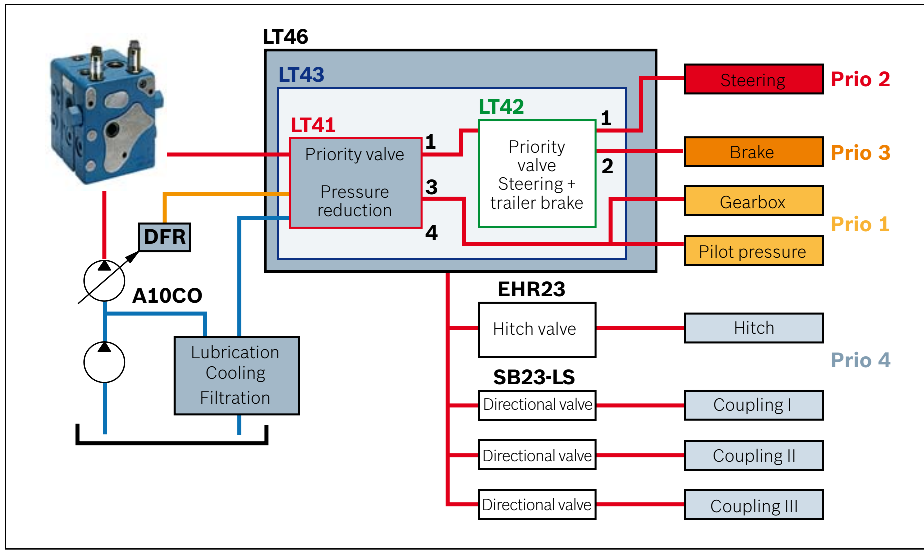


Fig. 5.51: Priority functions in the Rexroth valve block LT 46 for LS systems with a variable pump

Priority valves	Preferred applications
Priority 23	▶ for valve series SB23 ▶ priority for steering or for constant pressure
Priority 12	▶ priority for steering or for constant pressure
CHP (LT...)	▶ for large oil flows ▶ with multiple priority functions (BV, steering, low pressure) ▶ with BV possible
Priority to AKP	▶ can be flanged onto AKP (A10...) ▶ 1 or 2 priority functions ▶ possible with BV
Priority in BV	▶ only priority for BV possible

Table 5.2: Variants of Rexroth priority valves

Imprint

Knowledge in Detail
Hydraulics in Tractors

Publisher:
Bosch Rexroth AG
Mobile Applications
Glockeraustrasse 4
89275 Elchingen, Germany

1st edition (June 2014)
Material number: R961009447
ISBN 978-3-9814879-9-2

The Drive & Control Company

Bosch Rexroth AG
Drive & Control Academy
Bahnhofplatz 2
97070 Würzburg, Germany
Phone: +49 9352 18-1920
Fax: +49 9352 18-1040
media@boschrexroth.de
www.boschrexroth.com/academy

This book provides an overview of the most important hydraulic functions of agricultural tractors and presents components and system solutions. These solutions – when engineered to the specific application – are also deployable to other mobile machines. The reader of this book should have a good knowledge of hydraulics and be familiar with the symbols used in hydraulic schematics to fully grasp and enjoy the information conveyed.

Material number: R961009447

9 783981 487992