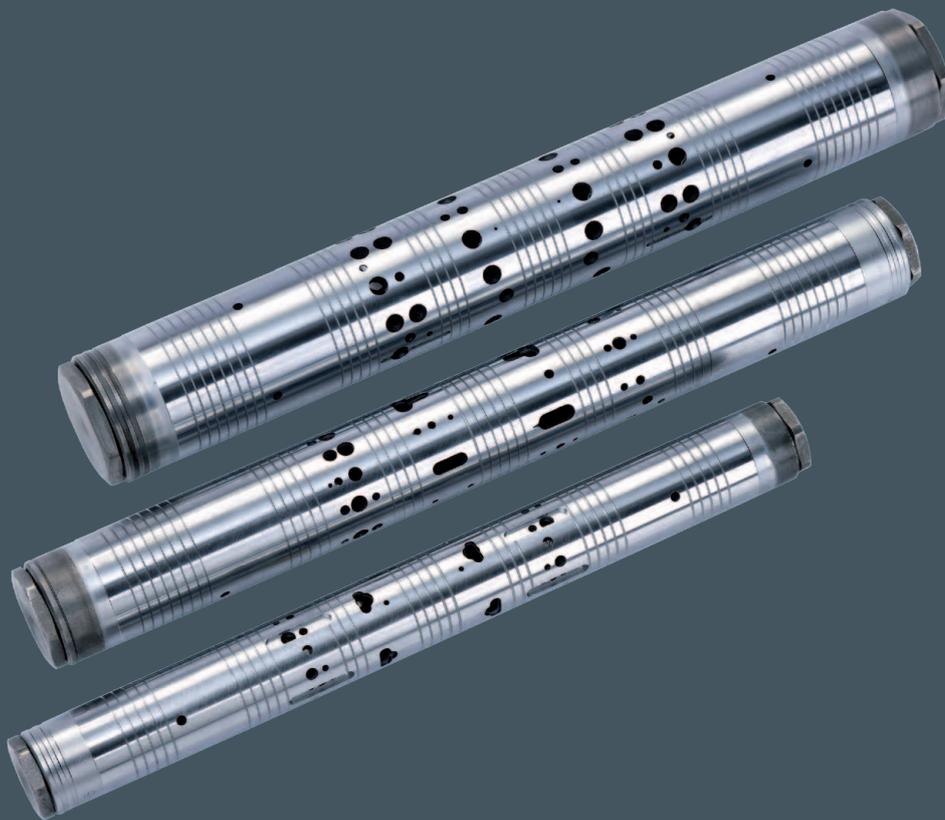


Performance meets Flexibility.  
LSC. Linde Synchron Control.

Linde Hydraulics

*Linde*

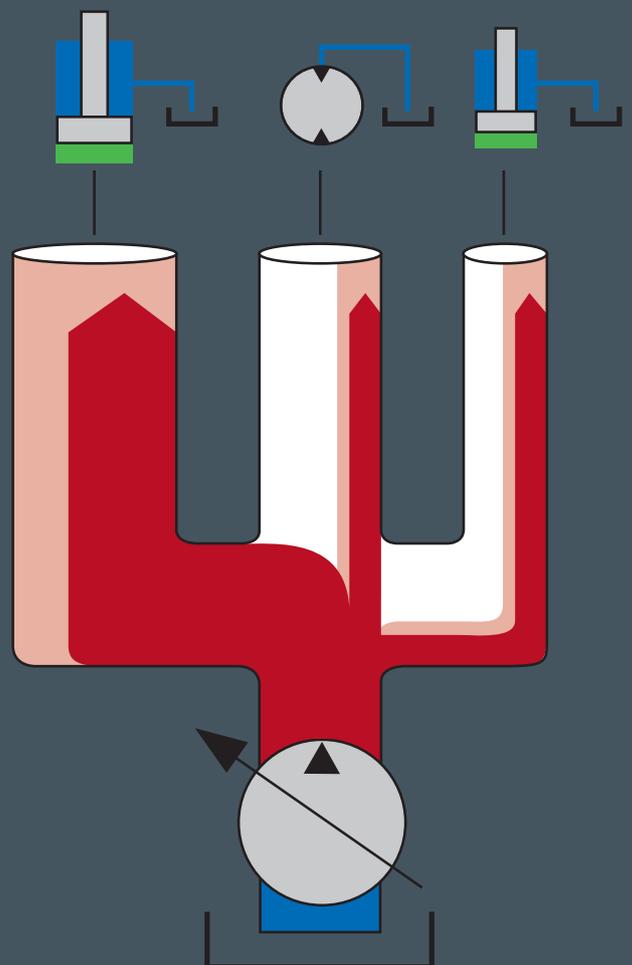


# Proportional Flow Distribution. Linde Synchron Control.

As a trailblazer in Load Sensing Technology Linde looks back on more than 25 years of experience in sophisticated open loop applications. **Linde Synchron Control (LSC)** has been present in the market since 1984. It is one of the first Load Sensing systems in the market which enables proportional flow distribution by use of downstream compensators.

When operating several actuators at the same time, the available oil is divided according to the requirements of these functions. If all functions actuated together demand a higher flow than can be provided by the pump, the system is saturated. In this case all actuator flows will be reduced evenly. The ratio of their flows to each other remains the same, no actuator will stop unexpectedly. Besides the simplicity of operation, this also has advantages regarding safety.

Besides the valves and the manifold plates of the LSC system Linde also offers all components required to equip a machine: Pumps, motors, electronic controls and peripheral components. This is enhanced by the Know-How and the decades of experience of the Load Sensing specialist.



- Demanded flow (150% pump capacity)
- Distributed flow (100% pump capacity)



## LSC Benefits.

### Efficiency meets Durability.

#### Maximum efficiency

On-demand flow control of the regulating pump and elimination of bypass flow losses due to the „closed center“ design of the directional control valves prevent wasting energy and fuel. Compared with other systems, LSC enhances fuel economy by up to 10%. Due to high materials handling capability as a result of sophisticated operability and performance, work is completed in the shortest possible time. This saves time and enhances efficiency.

#### Operational convenience

Sensitive, exactly reproducible control and compensation of loading effects enable intuitive operation of the machine and make readjustments unnecessary. Thanks to proportional flow distribution, the desired performance is always ensured, even under full load.

#### Maximum performance

Large internal dimensions of the directional control valves, rapidly responding regulating pumps of the series 02 and a system pressure of 420 bar characterize Linde products for open loop applications. They guarantee highest performance even in most demanding applications.

#### Long service life

Robust technology for the highest quality demands and a reliable design ensure high availability and long service life of LSC system components.

#### Flexible machine design

The LSC system enables the design of individual machines with distinct differentiation concerning function and reaction.

- adjustable starts and characteristics of functions, independently for side A and B
- adjustable response and machine reaction
- prioritizing of individual actuators
- simple addition of functions with the same base components as a result of the parallel system architecture

# 600 l/min



## The PowerFlow. Performance meets Flexibility.

For 25 years the LSC system has been characterized by excellent performance and high efficiency. With PowerFlow and the innovative modular system the LSC technology targets future requirements and trends of state-of-the-art machinery. Higher efficiency at lower fuel consumption, more power for the larger machines equipped with LSC and better flexibility for shorter product development cycles.

### Manifold base plates VT-01

Generously sized internal flow paths supply the sizes 25 and 30 of directional control valves with minimum losses and also enable further efficiency enhancement with existing valves.

The base plates series VT-01, which were specially developed for the modular design concept with optional electric piloting, serve as basis for modern machines.

### Nominal size 30 for directional control valves

A quantum leap in Load Sensing Technology. At the bauma 2010, Linde presented the directional control valve VW30 and pushed the flow limits of Load Sensing systems to 600 liters per minute in a globally unique way. For the first time ever the benefits of the LSC system are now also available for larger scale applications.

### Electric piloting

The base plates and monoblocks enable hydraulic controlling or electric piloting of the directional control valves with all the benefits of an intelligent electronic system control. The robustness of the LSC manifold valve plate remains unchanged. The solenoids are mounted to the valve manifold block in such a way, that they are well protected against environmental influences and mechanical loads.

### Modular concept for manifold valve plates

Thanks to uniform interfaces the new base plates can be simply configured to use a variety of directional control valves and intermediate plates for functional modification. Quick availability enables instant assembly of test vehicles and thus makes the LSC system attractive for even small production runs. Due to uniform interfaces, machines of different power classes can be equipped with an identical manifold block infrastructure. The manifold valve plate can be extended with accessory modules. This enables simple manufacture of identical basic machines with different equipment versions for various target markets. A high level of identical components for various manifold valve plates helps to manage the variations and saves inventory costs. In case of servicing, individual modules or components can be quickly and simply exchanged.

**Actuator 1**

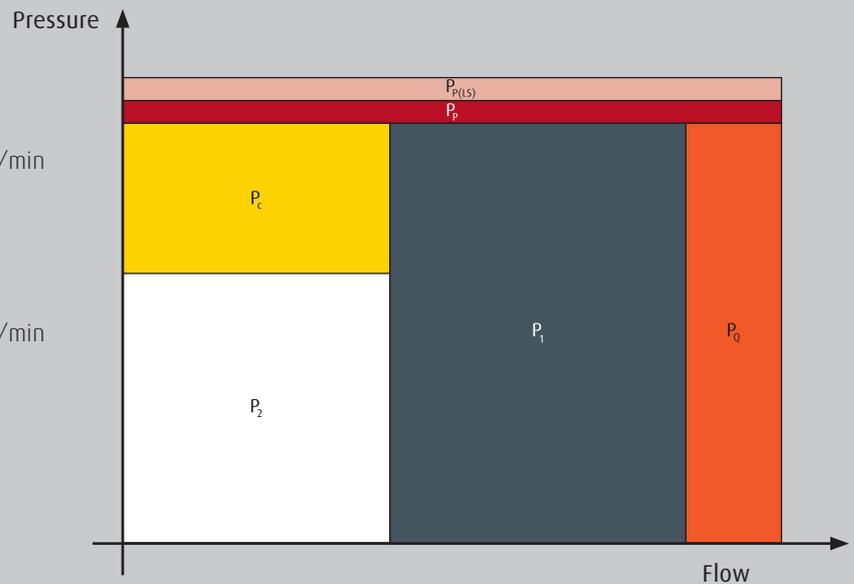
- Pressure level: 300 bar
- Required flow under partial load: 50 l/min
- Required flow under full load/saturation: 300 l/min

**Actuator 2**

- Pressure level: 200 bar
- Required flow under partial load: 50 l/min
- Required flow under full load/saturation: 300 l/min

**System**

- Power of diesel engine: 120 kW
- Capacity of pump: max. 400 l/min



## System comparison. NFC, PFC and LSC.

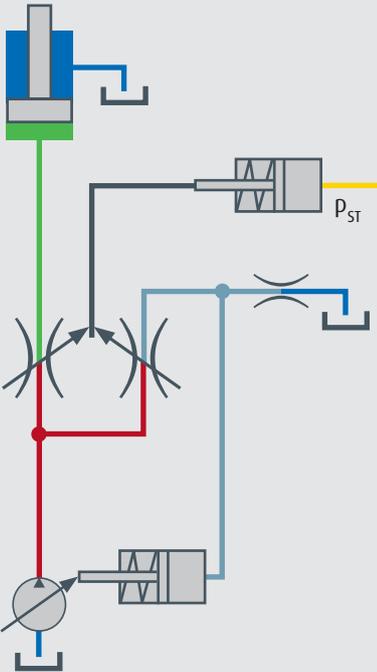
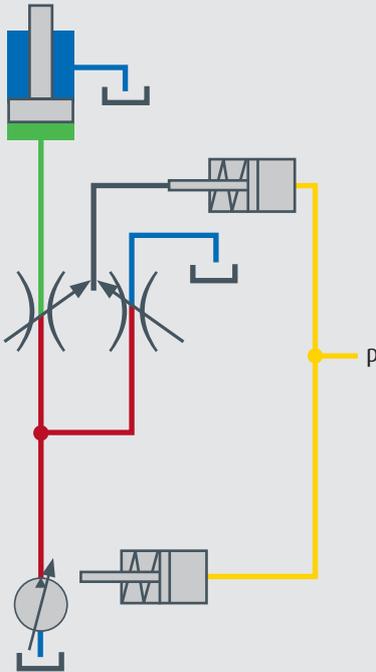
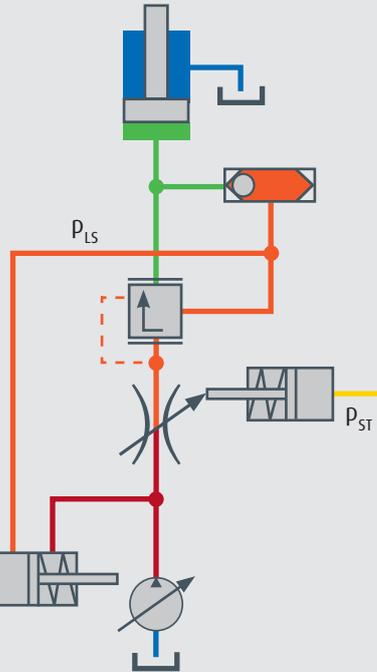
Around the world we find three main, but generally different concepts of open loop hydraulic systems. **Negative Flow Control (NFC)**, **Positive Flow Control (PFC)** and **Load Sensing (LS)**. In an unbiased comparison the Linde Synchron Control (LSC) has turned out to be clearly the most efficient system.

An example machine with a 120 kW diesel engine, a hydraulic pump with a flow rate of maximum 400 liters per minute and 2 actuators with the values described above, served as basis for this comparison.

The illustration above shows the power ranges of the two actuators and the resulting power losses.

Since both actuators are operated on different pressure levels, so-called compensation losses ( $P_c$ ), occur in the system, which equalize these differences. The power of the actuators ( $P_1$  and  $P_2$ ) as well as the resulting compensation losses ( $P_c$ ) are assumed to be almost identical in all systems. The comparison graphs on page 7 therefore only show the pressure related losses ( $P_p$  and  $P_{p(LS)}$ ) and flow related losses ( $P_q$ ) of the three systems in comparison.

# System comparison. The architecture.

NFC	PFC	LSC
		
<ul style="list-style-type: none"> <li>Dynamic pressure in bypass generates pilot signal</li> <li>Self-regulating pump</li> <li>Default = Vmax</li> <li>„open center“</li> <li>Continuous bypass flow</li> <li>No compensator</li> </ul>	<ul style="list-style-type: none"> <li>Evaluation logic generates pilot signal</li> <li>Variable displacement pump</li> <li>Default = Vmin</li> <li>„open center“</li> <li>Continuous bypass flow</li> <li>No compensator</li> </ul>	<ul style="list-style-type: none"> <li>Pressure demand generates pilot signal</li> <li>Self-regulating pump</li> <li>Default = Vmax</li> <li>„closed center“</li> <li>No bypass flow</li> <li>Secondary compensator</li> </ul>

### Functionality

The **NFC system** uses a measuring orifice in the bypass oil flow to generate a pressure signal, which influences the swash angle of the regulating pump.

In **PFC systems** the control signal is used to control both valve and pump. A complex evaluation control consisting of valve cascades in combination with software determines a certain swash angle for the pump. The algorithms are exactly matched to the individual machine with a fixed configuration. Operability and efficiency are trimmed for a specific, predefined application.

**Load Sensing** directional control valves are generally equipped with a compensator. The LSC system is equipped with a compensator for each actuator side. This compensator determines the pressure currently required at the actuator and feeds a pressure signal\* back into the LS line. All actuators share this LS line, irrespective of their number. The LS signal is the only signal the pump requires to provide short-term and on-demand flow under high pressure. Additional actuators are connected to the LS line and can thereby be simply integrated into the system. With this it is possible to fit differently equipped machines with a generally identical LSC system.

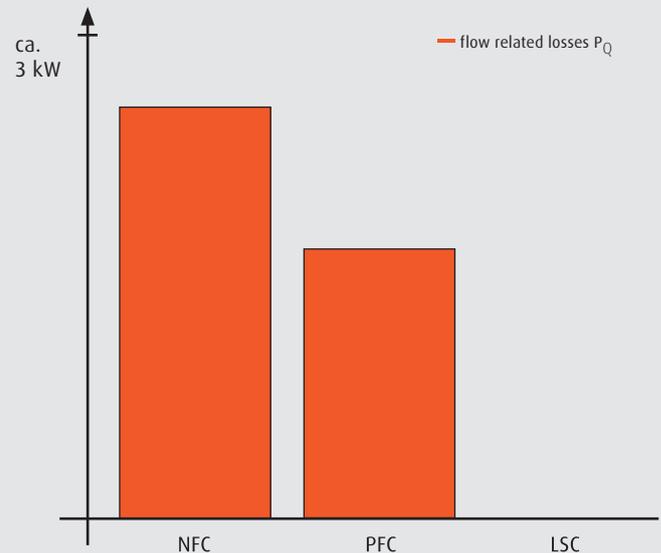
\* The graph on page 5 shows the resulting power as  $P_{p(LS)}$ .

# System comparison.

## Power losses under different load conditions.

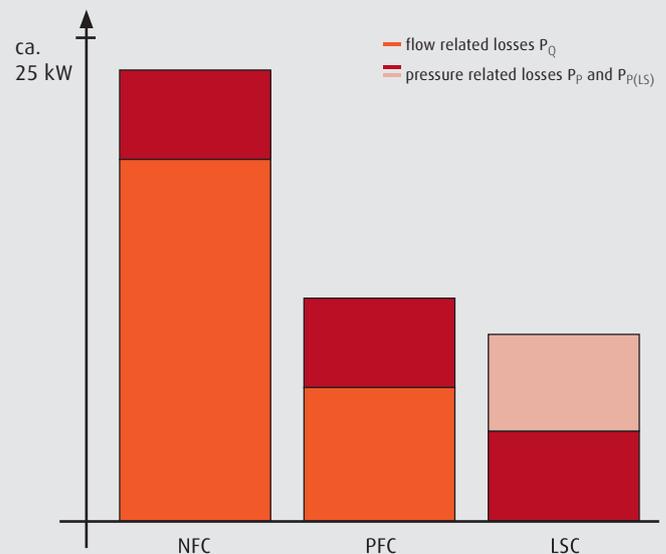
### No-load

If no actuator is operated, the directional control valves are in neutral position. NFC and PFC are so-called „open center“ systems. In these systems the pump and tank paths are connected in neutral position. This way the pump permanently delivers an unused flow through the valves back to the tank, in addition to the leakage. In the NFC system up to 50 liters per minute run unused through the machine, in the PFC system up to 30 liters per minute. Due to the corresponding dynamic pressures this results in considerable power losses ( $P_Q$ ). The directional control valves in the LSC system are designed as „closed center“ valves. Pump and tank paths are not connected in neutral position. Under no-load conditions the pump is regulated back towards zero. It generates a standby pressure of approx. 30 bar. However, since no oil is flowing, the power loss (product of pressure and flow) is zero.



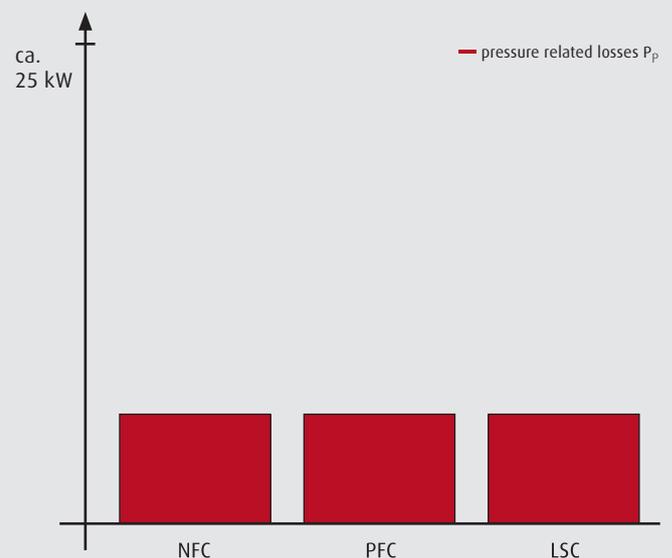
### Partial load

If an actuator is to be moved, the operator triggers a control signal. This signal is fed to the spool in the directional control valve. Under partial load one or several actuators are operated. The pump delivers the requested flow and generates the highest demanded pressure. NFC and PFC directional control valves reduce the flow from pump to tank to divert it to the actuators, but still continue feeding oil back into the tank. With the LSC system the pump flow is increased just enough to meet the demands of the corresponding actuators, because the pump does not need to compensate for any bypass flow losses. Even in this situation the pump is always operated under the most favorable conditions.



### Full load

If several actuators are operated at the same time and thus require more oil flow than the pump is able to deliver, the system is in saturation. In this condition the NFC and PFC systems no longer deliver any oil back to the tank. Besides the compensation losses, only pressure related losses are relevant. In the LSC system the  $\Delta p_{LS}$  drops because of the flow shortage. The pressure related losses of the three systems under full load are approximately identical.





## System comparison. Movement and operation behavior.

**Partial load. Load independent actuator movement without readjustment by operator.**

If, as in the example, several actuators need to be operated at different pressure levels, the pump needs to provide the pressure demanded by the actuator with the highest pressure requirement. With NFC and PFC systems the operator needs to take this into consideration and actuate or readjust the control elements on the machine as required for the number and pressure levels of the actuators. The LSC valve spool contains a compensator and pressure copier. The highest LS signal is always transmitted to the pump. The compensator in the directional control valve of an actuator on a lower pressure level automatically compensates for the pressure difference. The control signal does not need to be corrected. More load on the actuator generates a higher LS signal. The pump, in turn, provides a higher pressure and thereby compensates for load changes. The control signal is independent from the applied load. The operator never needs to make any readjustments. Apart from this, both compensator and pressure copier determine the load applied to the actuator, even before it is operated. The spool opens the passage between pump and actuator path only after the pressure level of the pump has reached the load pressure level. This ensures that a load will not drop before the start of operation.

**Saturation. Consistent Operation thanks to Proportional Flow.**

In the example both actuators together would demand 600 liters per minute from the pump which is only able to deliver 400 liters per minute. In NFC and PFC systems certain actuators, which are positioned lower in the control logic or have a pressure level which creates a higher resistance for the available oil flow, will stop while all of the flow goes to the main actuators. This is also the case in Load Sensing systems with upstream compensators.

The operator needs to reduce the flow to some actuators to supply other actuators with oil. Permanent control actions are required and make operation difficult.

In the LSC system the compensators are arranged downstream. For this reason one also refers to it as a „post compensated“ Load Sensing system. This enables the so-called „Proportional Flow“. The system can be operated as usual, even under saturation. The pump delivers the maximum flow. This flow is distributed to all actuators according to their proportional requirements. A fully operated actuator receives double the amount of oil as a half operated actuator with identical power. In the example both actuators receive 200 liters each. Neither function will stop.

# System comparison.

## Higher efficiency with LSC.

### Duty cycle

The duty cycle of a machine consists of no-load, partial load and full load phases. Statistically the combined movements of individual actuators in the partial load range make up the majority of the cycle time. The efficiency of differently equipped machines of the same power class can be compared by measuring the time and fuel consumption when performing identical duties.

Here the LSC system excels in both aspects. In machines with complex duties and varying applications, measurements confirm a 10% advantage in efficiency over competing systems. Pressure and flow are always made available as required at the optimal point in

time. The drive power is utilized efficiently, no energy is wasted. Thanks to the intuitive, load independent operation, machines with the LSC system achieve high productivity.

Owners of machines save twice: On the one hand they save on fuel, on the other hand in labor costs.

## Bottom line.

### More benefits.

#### Flexibility in machine design

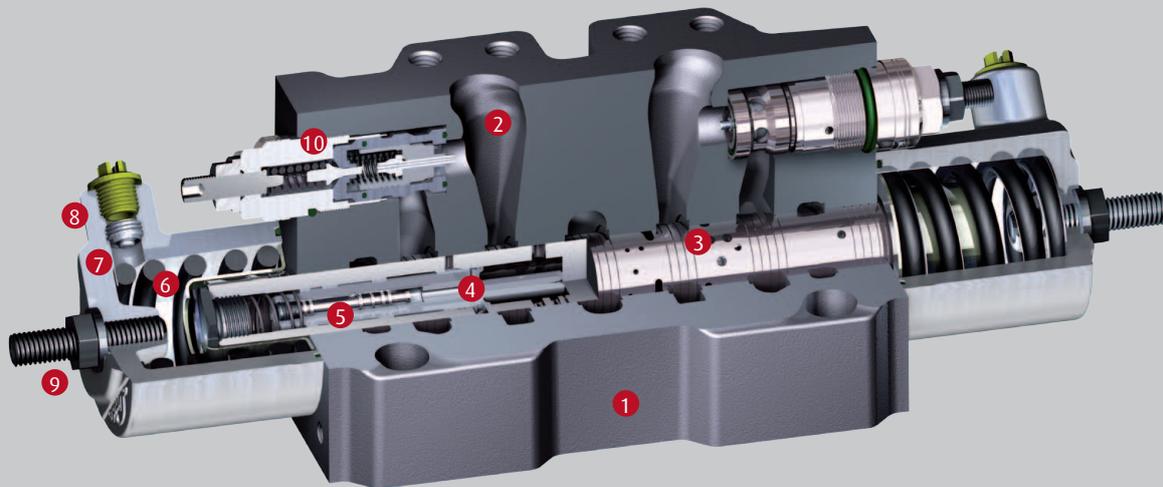
- simple, parallel interconnection of actuators with a common LS signal

#### High productivity

- compensation of load effects and simultaneous movement of several actuators, even in the case of saturation
- intuitive operation without readjustment
- extremely short actuating times of the regulating pump
- high machine dynamics

#### Excellent system efficiency

- low losses
  - save fuel
  - enable a smaller cooler design
- high productivity



## LSC directional control valves. Basis of individual machine characteristics.

Design characteristics directional control valves		
1	Load Sensing directional control valve	shown as sub plate mounted valve, alternatively available as sandwich valve
2	Cross-sections	thoroughly dimensioned in several nominal sizes
3	Valve control spool	with integrated compensators and pressure copiers
4	Compensator	downstream, for compensation, 1 per side
5	Pressure copier	integrated in compensator, 1 per side

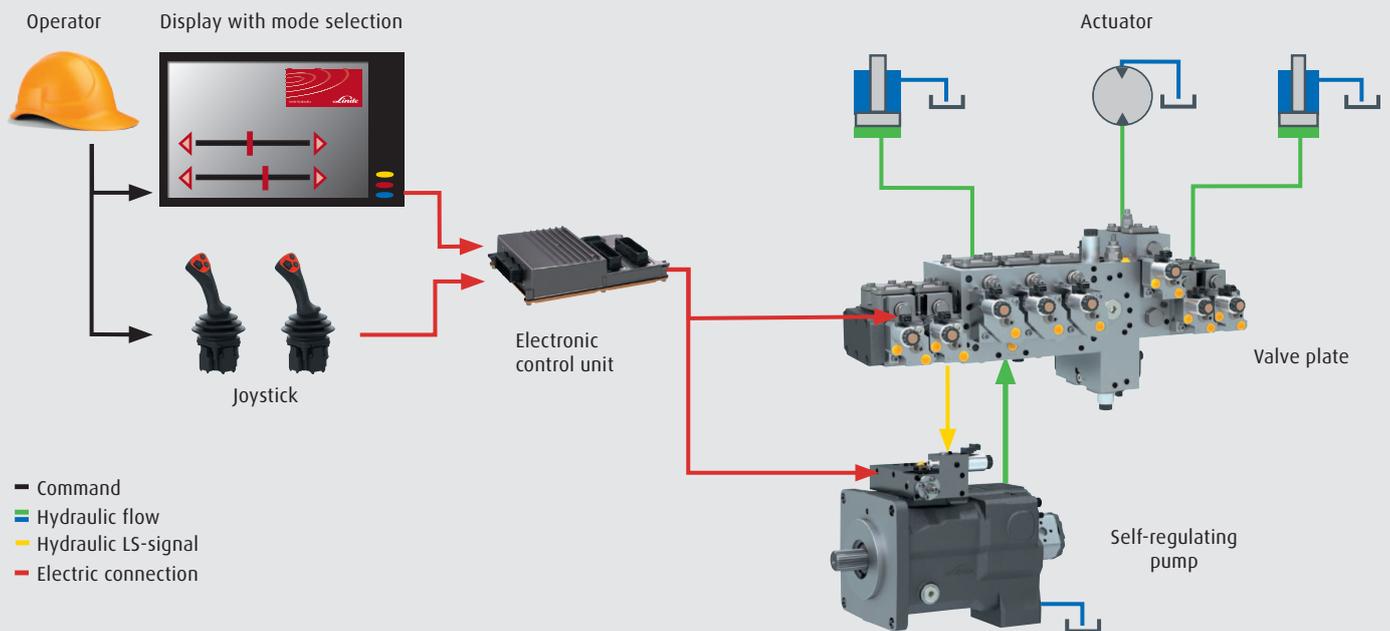
6	Centering spring	in 2 versions for 2 pilot pressure ranges
7	Shim	each side independently adjustable start of function
8	Throttle check valve	in pilot pressure port, adjusting valve dynamics
9	Mechanical stroke limiter	independent flow limitation on each side
10	Pilot-operated work port relief valves	with flat flow-pressure characteristic, make-up function optional

In LSC Technology the directional control valves are the heart of every manifold valve plate. Compared with other Load Sensing directional control valves, the LSC directional control valves are characterized by an integrated control spool design.

The control spool is precision ground to match the directional control valve housing, so that the clearances are quite small. There is very little leakage when the load is held without the actuator being operated. When a function is operated, the compensator will only open after the pump pressure has reached the load pressure level. This prevents lowering of the load at the start of the function, so that no separate load holding valve is required.

The compensators and pressure copiers are directly integrated in the control spool, making sure that the functional components do not need to be positioned at any other place in the valve. This has the advantage that the oil flow only needs to pass through the valve once and not several times. This ensures optimized flow passages in the directional control valve.

The behavior of an actuator can be individually adjusted to the desired characteristic by one compensator and one pressure copier at each side. With this, any physically dependent, different behavior of the actuator - for example when lifting and lowering - can be explicitly adapted.



## LSC<sup>+</sup> Adaptive electro-hydraulic control.

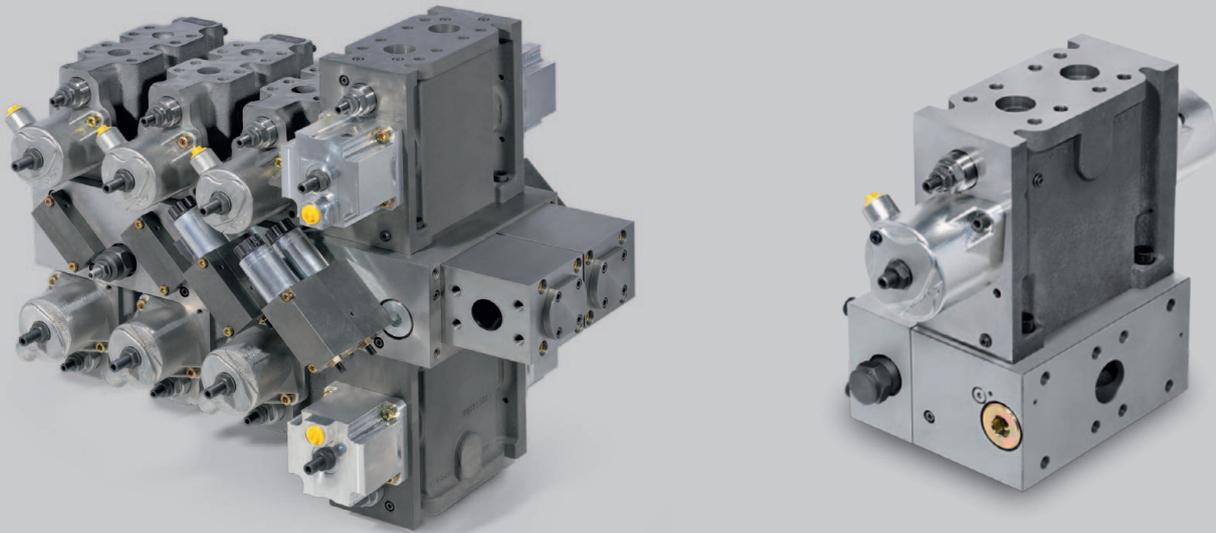
With its latest LSC generation, Linde combines the design characteristics of the proven LSC system with the benefits of the electric control. The powerful electronic control unit recognises the operator's command by the amplitude and the speed with which the joysticks are being moved. It then sets the pump and the valves according to the dynamic demand. Due to the overlaid, classic load-sensing control mechanism, no sensors are needed. All components are provided by a single source and matched perfectly with each other. The operator can change the system's behaviour electronically with regard to its dynamics and fine control, as well as its dependency or independency on the load. This enables multi-purpose machines which can quickly be optimized to the specific use by the operator. With completely opened valves, the actuators can be controlled exclusively via the pump's control to achieve the maximum possible efficiency.

### Design characteristics

- core components of the proven LSC system
- robust system without sensors
- electric control of pump and valve plate
- suitable for single circuit and intelligent multiple circuit systems
- simple control via CAN-interface for the display

### Product advantages

- direct response behaviour
- most simple machine operation
- further increase in energy efficiency
- automatic recognition of the working condition in high dynamic or fine control mode
- automatic optimization of typical tasks like grading or shaking the bucket of an excavator
- manual adjustment of load dependent or load independent system behaviour and system dynamics by the operator
- optional prioritization of actuators with each other enables an adjustment to the current situation, like e.g. the space curve



## VT modular. More flexibility.

Manifold valve plates of series VT modular are made up of individual components of a modular building block system. This is why manifold valve plates can be configured to optimally match any application with one up to eight actuators.

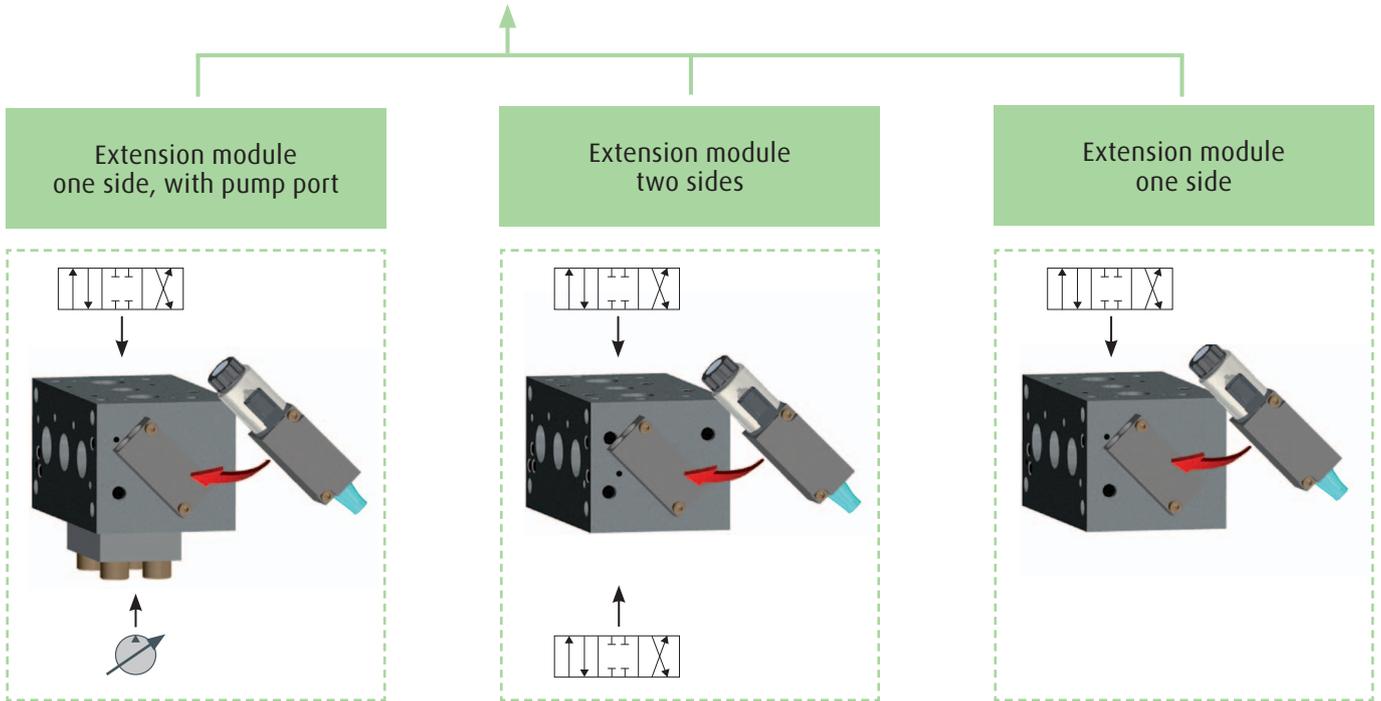
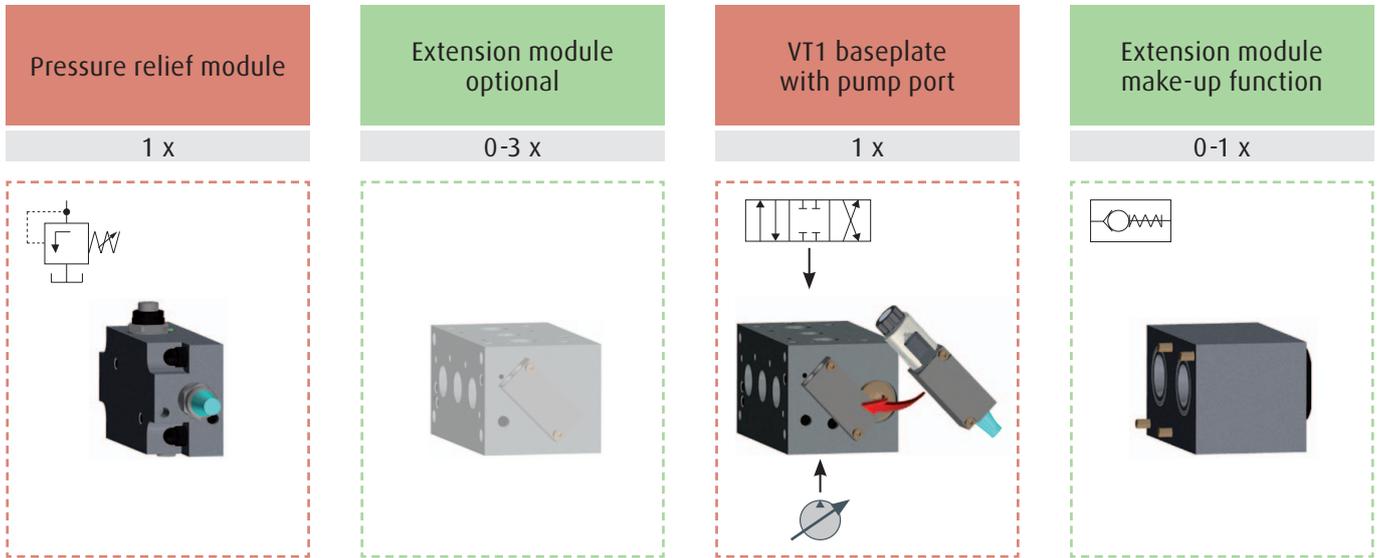
### Design characteristics

- directional control valves available as sub plate mounted valves
- designed for the Linde Synchron Control (LSC) - Load Sensing System
- nominal sizes 25 and 30
- flows up to 600 l/min (size30)
- modular design for the configuration of valve plates for 1-8 actuators
- optionally with hydraulic, electric or combined piloting

### Product advantages

- all advantages of the LSC valve technology
- easy to configure building block system
- adjustable to the target application
- quick availability
- ideal for machines with low production volume

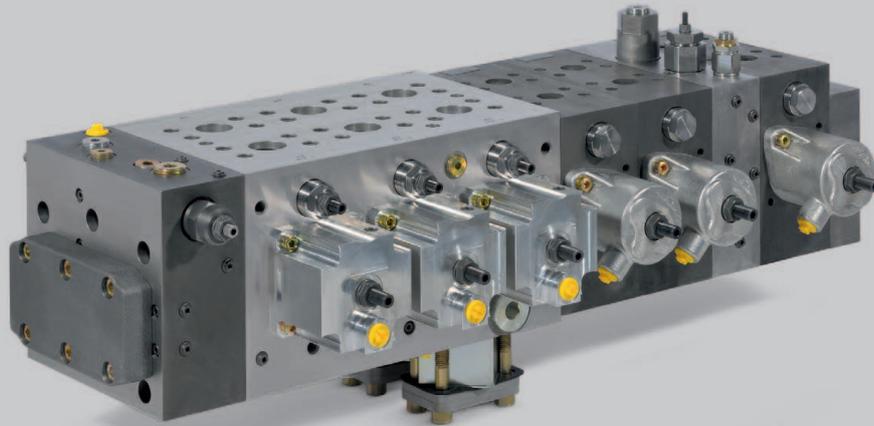
# VT modular. Configuration.



Legend

-  Pump port
-  Electric piloting (optional)
- Extension module (optional)
- Standard module (mandatory)





## Monoblock. Compact design.

Three directional control valves in a common housing form the base of the manifold valve plate in monoblock design. This results in the most compact package.

### Design characteristics

- basic block: three directional control valves of identical nominal size in one cast housing
- designed for the Linde Synchron Control (LSC) - Load Sensing System
- nominal sizes 30, 25 and 18
- flows up to 600 l/min (size 30)
- broad dimensioned diameters and flow-optimized design of the supply channels
- extendable with directional control valves in sandwich design, in identical or differing nominal size
- pressure cut-off and additional functions integrated in connection plate
- special functions via intermediate plates
- optionally with hydraulic or electric piloting

### Product advantages

- all advantages of the LSC valve technology
- compact design
- full-size expandability
- high efficiency achieved by flow-optimized channels even for applications with numerous actuators

# Monoblock. Configuration.

## Rated size 30

<b>Cover</b>	<b>VW18S</b> Sandwich Valve Size 18	<b>PRB</b> Pressure Relief Block	<b>VW30S</b> Sandwich Valve Size 30	<b>VW30M3</b> Base-Monoblock with 3 Valves Rated Size 30	<b>VW25S</b> Sandwich Valve Size 25	<b>VW18S</b> Sandwich Valve Size 18	<b>Cover</b>
1 x	0-3 x	1 x	0-3 x	1 x	0-3 x	0-3 x	1 x

## Rated size 25

<b>Cover</b>	<b>VW18S</b> Sandwich Valve Size 18	<b>PRB</b> Pressure Relief Block	<b>VW30S</b> Sandwich Valve Size 30	<b>VW25M3</b> Base-Monoblock with 3 Valves Rated Size 25	<b>VW25S</b> Sandwich Valve Size 25	<b>VW18S</b> Sandwich Valve Size 18	<b>Cover</b>
1 x	0-3 x	1 x	0-3 x	1 x	0-3 x	0-3 x	1 x

## Rated size 18 (in preparation)

<b>Cover</b>	<b>VW14S</b> Sandwich Valve Size 14	<b>PRB</b> Pressure Relief Block	<b>VW18S</b> Sandwich Valve Size 18	<b>VW18M3</b> Base-Monoblock with 3 Valves Rated Size 18	<b>VW14S</b> Sandwich Valve Size 14	<b>Cover</b>
1 x	0-3 x	1 x	0-3 x	1 x	0-3 x	1 x

**Legend**

Standard modules (mandatory):

- Monoblock VWxxM3
- Cover

Extension modules (optional):

- PRB Pressure Relief Block, with or without make-up module for cooler/tank
- Sandwich Valve Plate VWxxS

VW30  
up to 600 l/min

VW25  
up to 400 l/min

VW18  
up to 250 l/min

VW14  
up to 180 l/min

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