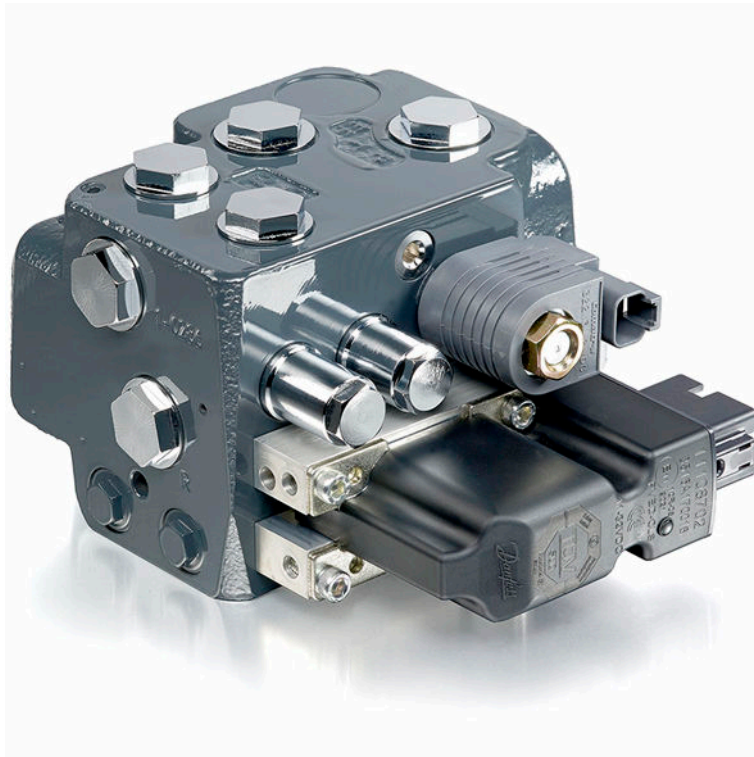


Technical Information

Steering

EHi Steering Valve



Revision history

Table of revisions

Date	Changed	Rev
January 2018	Function, Technical Characteristics, Coding ; minor corrections and additions	0202
April 2017	Updated some function drawings; added to EHi and system safety; Corrected Code numbers specifications; and minor corrections	0201
January 2017	First edition	0101

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Overview

A wide range of steering components



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Danfoss is one of the largest producers in the world of steering components for hydrostatic steering systems on off-road vehicles. Danfoss offers steering solutions both at component and system levels. Our product range makes it possible to cover applications of all types, ranging from ordinary 2 wheel steering (also known as Ackermann steering) to articulated steering, automatic steering (for example, by sensor) and remote controlled steering via satellite. We can offer more than 1,800 different steering units and 250 different priority valves categorized in types, variants and sizes.

For hydrostatic steering systems, Danfoss offers:

- Mini steering units with displacements from 32 to 100 cm³/rev [1.95 to 6.10 in³/rev], flow up to 20 l/min [5.28 US gal/min], steering pressure up to 140 bar [2030 psi].
- Steering units with displacements from 40 to 1200 cm³/rev [2.44 to 73.2 in³/rev], flow up to 100 l/min [26.4 US gal/min], steering pressure up to 240 bar [3481 psi].
- Priority valves for rated flows at 40, 80, 120, 160 and 320 l/min [10.6, 21.1, 31.7, 42.3 and 84.5 US gal/min], pressure up to 350 bar [5076 psi].
- Pilot operated flow-amplifiers with amplification factors of 4, 5, 8, 10 or 20 for rated oil flows of 240 and 400 l/min [63.4 and 105.7 US gal/min], steering pressure up to 240 bar [3480 psi].
- Pilot operated steering valve with steering flow up to 100 l/min [26.4 US gal/min], steering pressure up to 250 bar [3625 psi] and with integrated priority valve for pump flow up to 120 l/min [31.7 US gal/min].

For electrohydraulic steering systems Danfoss offers:

- Pilot operated steering valves (pilot operated by hydrostatic steering unit or by electrical signal) with steering flows up to 100 l/min [26.4 US gal/min], steering pressure up to 250 bar [3625 psi].
- Steering units with integrated electrical operated steering valve with steering flow up to 50 l/min [13.2 US gal/min], steering pressure up to 210 bar [3045 psi].
- Electrical operated steering valve with steering flow up to 70 l/min [18.5 US gal/min], steering pressure up to 210 bar [3045 psi].

Characteristic features for steering units:

- Low steering torque: From 0.5 N·m to 3 N·m in normal steering situations
- Low noise level
- Low pressure drop

Overview

- Many types available: Open center Non-reaction, Open center Reaction, Power Beyond, Closed center Non-reaction, Load Sensing, Load Sensing Reaction
- One or more built-in valve functions: relief valve, shock valves, suction valves, non-return valve in P-line and in LS-line
- Optional port connections (according to ISO, SAE or DIN standards)

Characteristic features for electrohydraulic steering systems with OSPE, EHPS, and EHi:

- Possibility of GPS, row sensor, variable steering ratio and joystick steering
- The possibility of manual steering even on very heavy vehicles
- EHPS: High steering pressure requiring smaller cylinders and flow
- EHPS: Low pilot pressure and flow giving extremely low noise in the cabin
- EHPS: Can be combined with Danfoss PVG 32 proportional valve

Conversion factors

1 N·m = [8.851 lbf·in]	1 l = [0.264 US gal]
1 N = [0.2248 lbf]	1 bar = [14.5 psi]
1 mm = [0.0394 in]	°F = [1.8°C + 32]
1 cm ³ = [0.061 in ³]	

Survey of literature with technical data on Danfoss steering components

Detailed data on all Danfoss steering components and accessories can be found in our steering component catalogues, which is divided in to the following individual sub catalogues:

General information	Steering components
Technical data on mini steering units	OSPM
Technical data on open center, and closed center steering units	OSPB, OSPC, and OSPD
Technical data on load sensing steering units, priority valves and flow amplifiers	OSPB, OSPC, OSPF, OSPD, OSPL, OSPBX, OSPLX, OVPL, OLS and OSQ
Technical data on load sensing steering unit with amplification	OSPU
Technical data on hydraulic and electrohydraulic pilot operated steering valves, electrical actuation modules and appropriate steering units.	EHPS, EHPS w. OLS 320, PVE for EHPS and OSPCX
Technical data on combined steering unit/ electrohydraulic steering valves and steering wheel sensors	OSPE
Technical data on electrohydraulic steering valves	EHi
Technical data on steering wheel sensors	SASA

For technical information on individual variants, please contact the Danfoss Sales Organization.

Overview

Electrohydraulic Steering Valve

On tractors, harvesters, sprayers and other similar vehicles, electrically actuated steering to make auto guidance possible is often needed. Also, manual steering with variable ratio is a preferred feature to improve productivity and driver comfort.

On wheel loaders, fork lift trucks and similar type of vehicles, the productivity and driver comfort can be increased significantly for off road usage, by using joystick or mini wheel for steering.

Danfoss has developed the Electrohydraulic Steering Valve (EHi) for electrohydraulic steering, controlled by electrical input signal either from GPS receiver/controller for auto guidance, or from steering wheel sensor (Danfoss type SASA) for variable steering ratio. In variable steering mode, the electrohydraulic valve adds flow to the metered flow from the OSP steering unit. Alternatively, the EHi can be activated by joystick or mini wheel.

The EHi design supports category 3 architecture according to ISO 13849-1. Fail-safe operation of electrohydraulic steering is achieved by means of two individual spools, both supporting medium diagnostic coverage 90-99%. The EHi is available with PVED-CLS steering valve controller to complete a full CAT3 fail-safe steering valve. The PVED-CLS has steering specific functions, including dedicated safety functions, which may be tailored for most off-road vehicles through software parameterization. The EHi is offered with an independent 3rd party certification and a full steering sub-system specification.

EHi will be the natural choice, if space does not allow to use the combined steering unit and electrohydraulic steering valve, type OSPE. With OSPE, installation will be very easy due to all functions for manual and electrohydraulic steering is integrated in the one and same unit.

The EHi is designed for easy integration with other components in a steering system. EHi manifold ports allows for building a steering system without the use of T fittings.

Versions

Versions, overview

Parts and variants

Part	Variants						
EH	EHi	Single section Electrohydraulic in-line (EHi) steering valve					
EH spool, directional	Cylinder flow, nominal, l/min	12	20	30	40	50	70
Concept	Steering unit type or Steer by Wire	Open center: OC	Closed center: CC	LS dynamic: LD	LS static: LS	Steer by Wire: W1 or W2	
Reaction	Reaction Switch Valve, RSV	Not included: N			Included: R		
Disengage	How to override EH steering	With steering unit:			Steer by Wire: Not relevant		
		Electric signal, from e.g. SASA sensor: E		Hydraulic override from steering unit: H			
PVE Actuation module	Type	PVED CLS SIL 2		PVED CC		PVES	
Coil, Voltage	Voltage, V	12			24		
Priority valve	For pump flow, nominal, l/min	45		90		None if priority valve is not needed inside EHi	
Relief valve	P-T, bar.	Always included: Setting value, max 210 bar					
Shock valves	R-T/L-T, bar	Included: setting value, max 280 bar			Not included		

Base type designation, example: **EHi 20 LD N E**

- 20 is referring to nominal cylinder flow, named xx in examples
- LD, N and E is referring to steering concept

Steering concept

EHi is offered in various versions to match the base steering unit on the vehicle.

EHi is available for:

- OC: Open Center steering units
- CC: Closed Center steering units
- LD: Load Sensing Dynamic steering units
- LS: Load Sensing Static steering units
- LC: Load Sensing Dynamic and Static steering units (universal configuration of EHi for LS steering units, normally to be chosen for after-market usage)
- N: Non reaction type steering units
- R: Reaction type steering units (except for steering systems with Closed Center steering units, which are not available with Reaction feature)

EHi is also offered in versions for pure Steer by Wire usage, meaning no hydrostatic steering unit is present in the steering system. EHi is available for:

- W1: Single EHi in Steer by Wire system or for the second EHi in Steer by Wire system with two EHi's
- W2: First EHi in Steer by Wire system with two EHi's, for example, when having two steering axis

Versions

Disengage of EH steering

In any steering system having a hydrostatic steering unit for the base steering, the steering wheel steering must have priority. The concept for deactivating the electrohydraulic steering must be considered and decided. Disengage of EH steering by:

- E: Electric signal detecting steering wheel rotation, for example, from Danfoss steering wheel sensor, type SASA
 - Electrical disengage is recommended
- H: Hydraulic signal from steering unit overrides electrohydraulic steering
 - Disengage of EH steering is available with the PVED-CLS actuator

[Variable steer mode is not available when using hydraulic disengage.](#)

Actuation of EHi steering valve

EHi is offered with different types of PVE actuators:

- PVED CLS: CAN ISOBUS controlled actuator with configurable electrohydraulic steering functionalities such as auto guidance, variable steering ratio, speed dependent characteristics, AUX interface for joystick and electric mini wheel, and with safety functions including controlling the EH cut-off valve. Can also handle up to 3 analogue inputs. See *OSPE with PVED-CLS Steering Valve Controller Data Sheet, L1309911* for further details. PVED CLS is recommended as actuator for EHi.
- PVED CC: CAN ISOBUS controlled actuator without dedicated software for steering. See *PVED-CC, Series 5 ISObus Technical Information, BC00000322* for further details. To be used if EH steering functionalities and steering safety must be controlled by external controller, for example, vehicle main controller
- PVEs: Ratio metric analog voltage controlled actuator without dedicated software for steering. See *PVE Series 7 Technical Information, BC00000378* for further details.

Priority valve

EHi is offered with and without integrated priority valve.

Pilot relief valve

Pilot relief valve is present in any EHi. Internal connection of pilot relief valve inside EHi is dependent on the pilot relief valve being present in the steering unit or not.

Shock valves

EHi is offered with or without shock and suction valves. Shock and suction valves are needed if they are not present elsewhere in the steering system. If shock and suction valves are present in the steering system, and always connected to the cylinder ports, additional shock and suction valves inside the EHi will not be needed. Activation of shock valves may produce an audible noise.

Versions

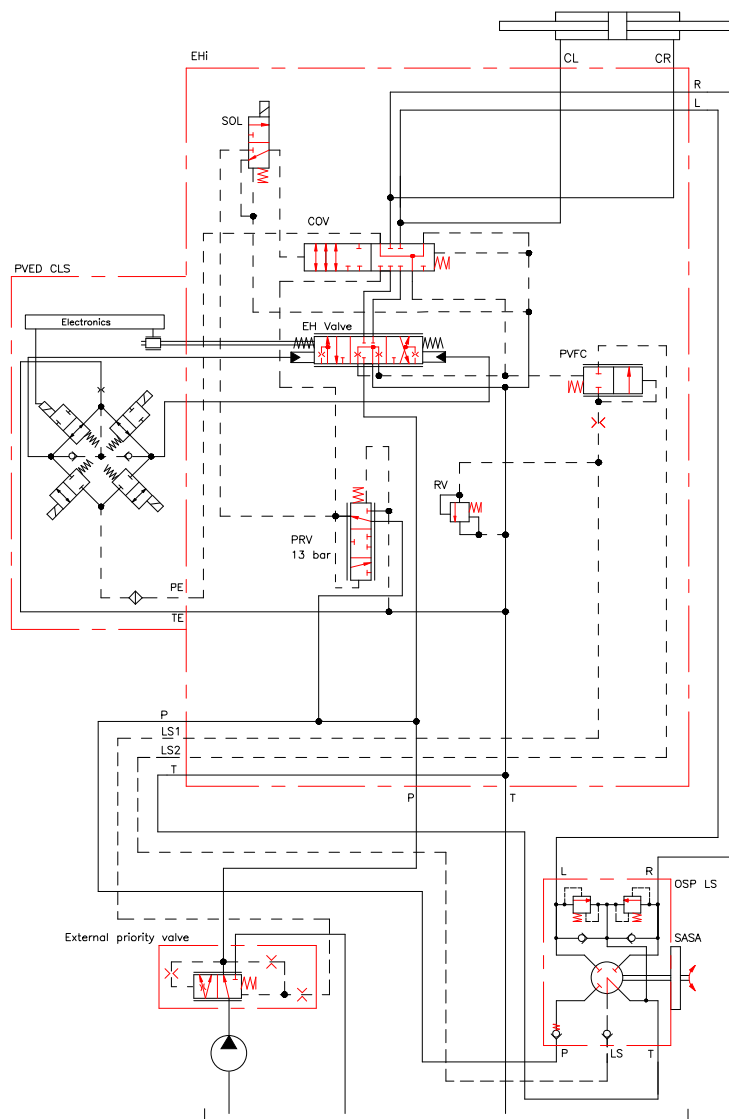
Versions, examples

EHi for Load Sensing None reaction steering system

EHi xx LD NE

This version is to be used in steering systems with LS Dynamic None Reaction steering unit and using SASA sensor for electrical disengage of EH steering. Priority valve is present outside EHi steering valve. EH steering will be disabled, when the electric power is shut down for the solenoid valve (SOL).

Configuration number: EHi-1



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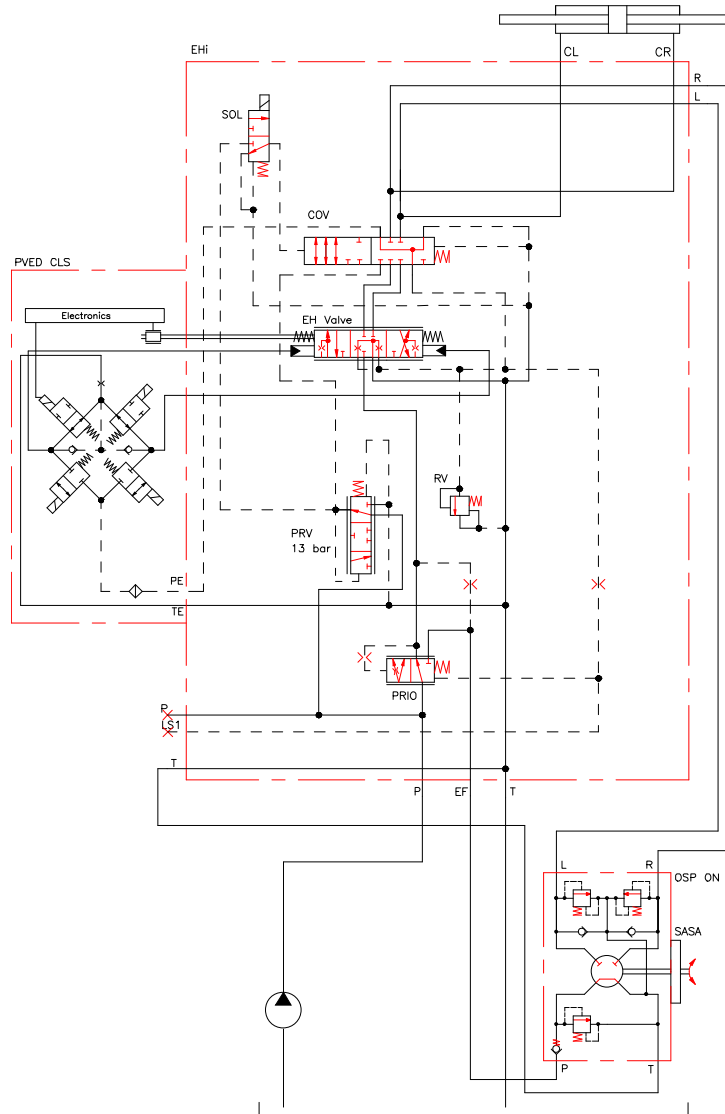
Versions

EHi for Open Center None reaction steering system

EHi xx OCNE

This version is to be used in steering systems with Open Center Non Reaction steering unit and using SASA sensor for electrical disengage of EH steering. Priority valve is present inside EHi steering valve. Priority valve is needed to generate stand by pressure across the EH directional valve. EH steering will be disabled, when the electric power is shut down for the solenoid valve (SOL).

Configuration number: EHi-2



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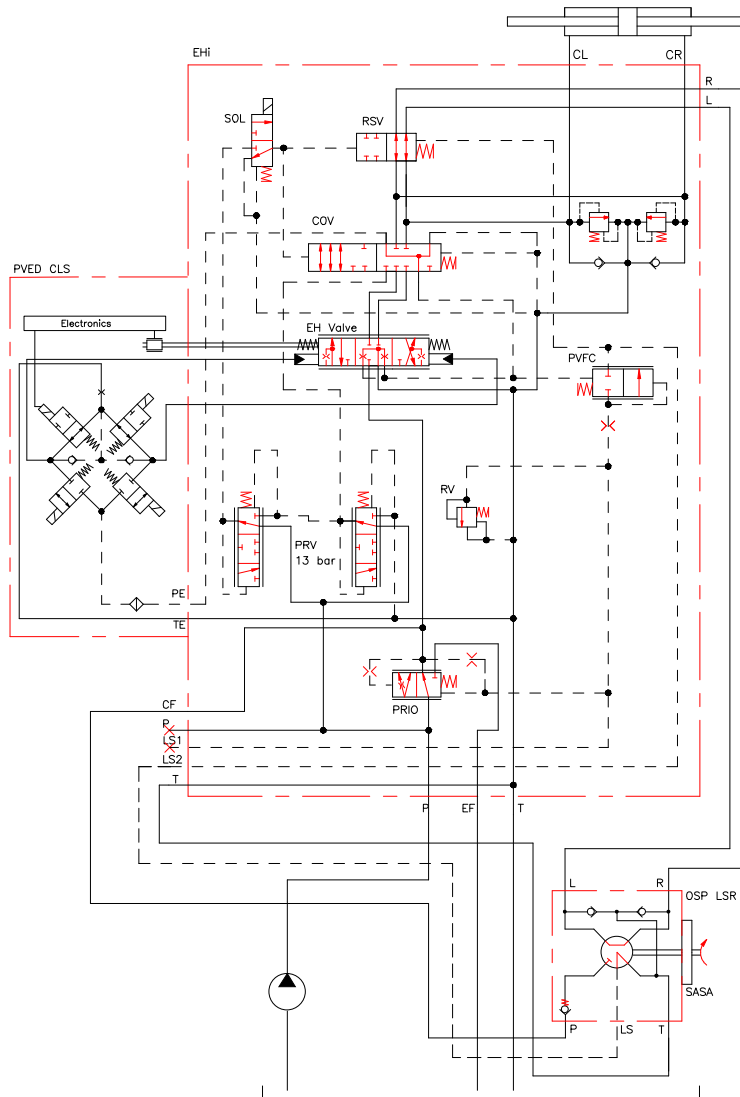
Versions

EHi for Load Sensing Reaction steering system

EHi xx LDRE

This version is to be used in steering systems with LS Dynamic Reaction steering unit and using SASA sensor for electrical disengage of EH steering. Priority valve is needed inside EHi steering valve, when no priority valve is present elsewhere. EH steering will be disabled, when the electric power is shut down for the solenoid valve (SOL).

Configuration number: EHi-5



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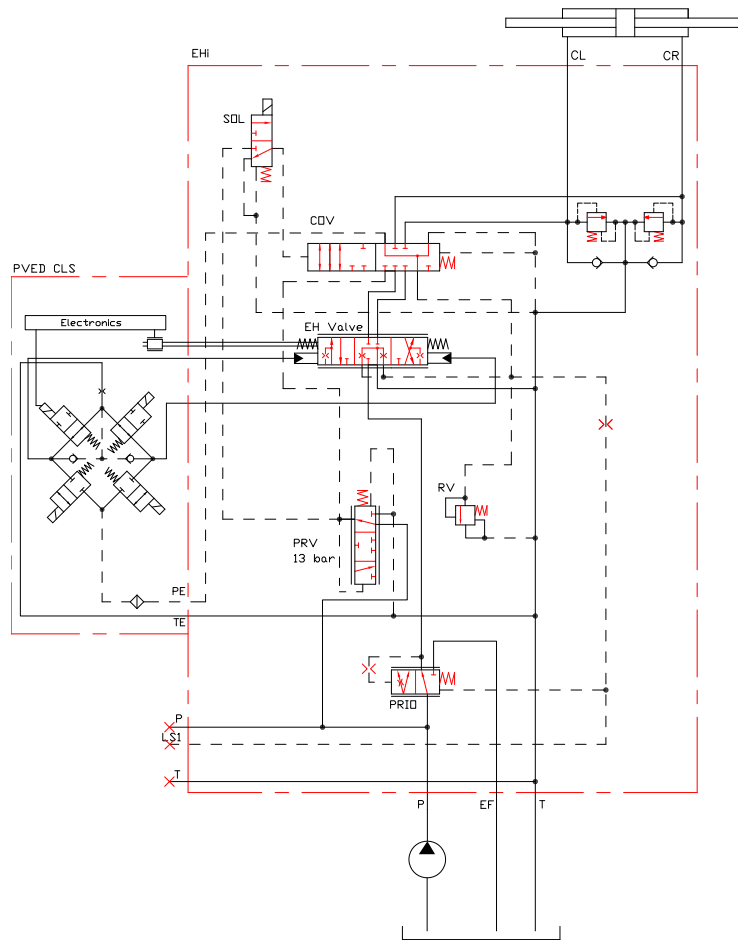
Versions

EHi for Steer by Wire steering system

EHi xx W1 N

This version is to be used in a fail-safe Steer by Wire steering system. Only the EHi valve can control the steering cylinder. Priority valve is needed inside EHi steering valve to generate stand by pressure across the directional spool. Engage and disengage of the EH steering can be controlled by a PVED CLS actuator or by a vehicle controller. EH steering will be disabled, when the electric power is shut down for the solenoid valve (SOL).

Configuration number: EHi-7

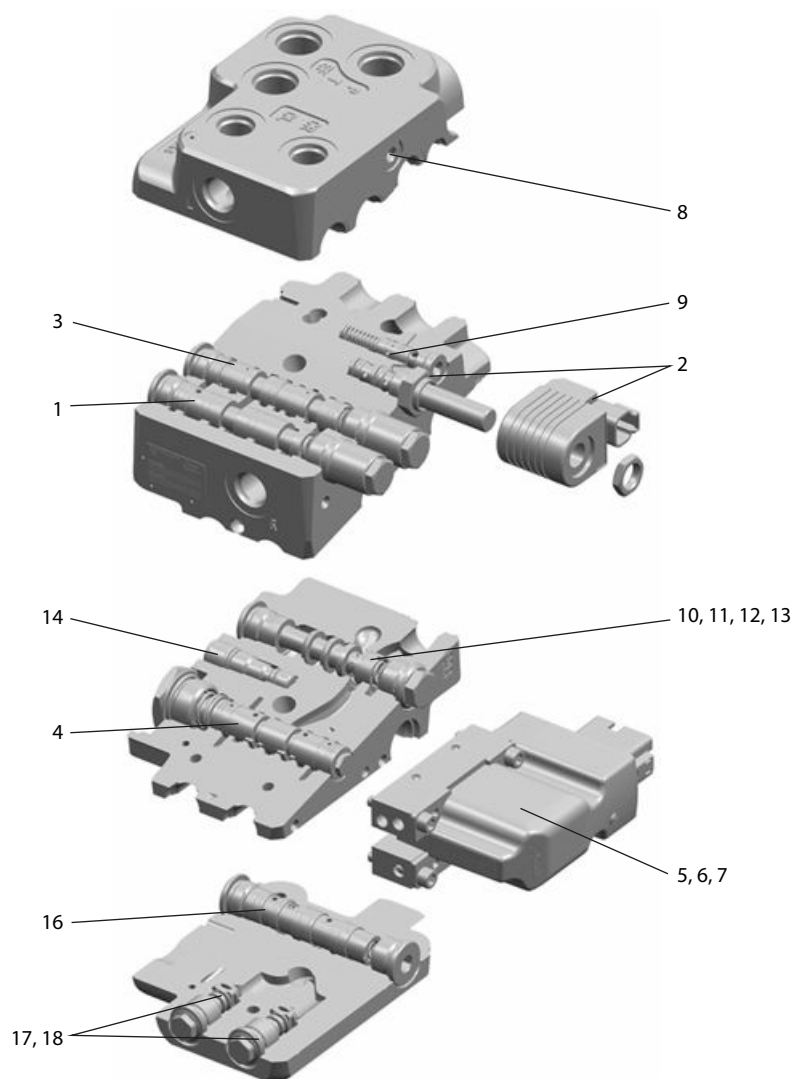


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Function

Main components

The EHi Steering Valve main components



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1.	RSV: Reaction Switch Valve	10.	PP damping orifice
2.	SOL: Solenoid control valve for EH cut off valve and RSV	11.	Priority valve spool
3.	COV: EH cut off valve	12.	Priority valve spring
4.	EH directional valve	13.	Dynamic orifice
5.	PVE control unit	14.	Pilot pressure relief valve
6.	Spool position sensor LVDT	15.	LS orifice (not shown in image)
7.	Solenoid valve bridge	16.	PVFC valve/LS resolver
8.	Pilot reduction valve, 13 bar, SOL-PE	17.	Suction valves
9.	Pilot reduction valve, 13 bar, PE-T	18.	Shock valves

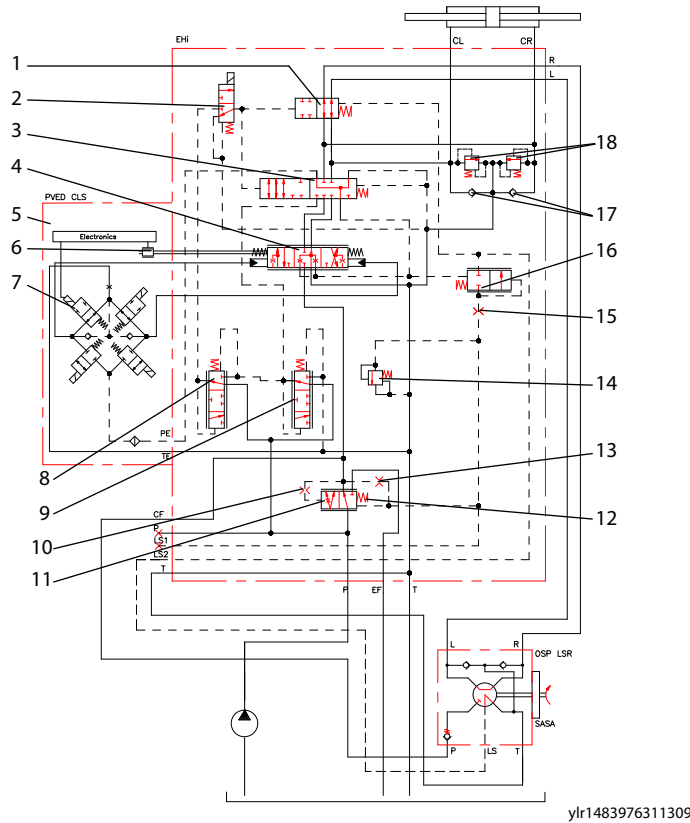
Function

EHi xx LD R E for Reaction type steering unit

EHi for Load Sensing Dynamic Reaction OSP Steering unit, electrical disengage of EHi by SASA Steering Wheel Sensor.

Configuration number: EHi-5

Neutral position



1.	RSV: Reaction Switch Valve	10.	PP damping orifice
2.	SOL: Solenoid control valve for EH cut off valve and RSV	11.	Priority valve spool
3.	COV: EH cut off valve	12.	Priority valve spring
4.	EH directional valve	13.	Dynamic orifice
5.	PVE control unit	14.	Pilot pressure relief valve
6.	Spool position sensor LVDT	15.	LS orifice
7.	Solenoid valve bridge	16.	PVFC valve/LS resolver
8.	Pilot reduction valve, 13 bar, SOL-PE	17.	Suction valves
9.	Pilot reduction valve, 13 bar, PE-T	18.	Shock valves

When the engine is turned off, the priority valve spool (11) is pushed to the left by the priority valve spring (12). The passage to the EF port is blocked. The passage to the EH directional valve spool (4) and to the CF port of EHi is open. The P-port of the OSP LSR steering unit is connected to CF port of EHi.

When the engine is on and the steering unit OSP and the EH directional valve (4) is in neutral position, the CF pressure will rise to match the spring force in the priority valve, consequently the priority valve spool (11) will move to the right and the main pump flow will pass from P port of EHi across the integrated priority valve spool (11) and out through the EF port. The priority valve is a “dynamic” type, meaning, when pump is on, a minor oil flow passes from CF through the Dynamic orifice (13) integrated in priority

Function

valve spool (11), the LS orifice (15), the PVFC valve/LS resolver (16), out of LS2 port of EHi and into the LS port of the OSP steering unit. In OSP the flow in LS line streams into the spool/sleeve set and in neutral position this dynamic oil flow passes on to tank.

When the OSP LSR reaction type steering unit is in neutral position and the solenoid control valve (2) is deactivated, then the steering system has Reaction features: the RSV valve (1) makes connection between the cylinder ports, CL and CR, through L and R of OSP. If the steering wheel is untouched and a delta P is generated in the steering cylinder, e.g. from self-aligning of the steered front axle, oil will pass from L to R or R to L through the spool/sleeve set and gear set of the OSP steering unit and the steering wheel will rotate until it is grabbed or delta P disappears. Only the force of the neutral spring package inside the OSP has to be overcome to stop to rotation of the steering wheel and so stop the cylinder movement/reaction feature.

When the SOL: Solenoid control valve for EH cut off valve (2) is deactivated, the COV: EH cut off valve (3) will prevent unintended EH steering, because CL and CR connections from EH directional valve (4) are blocked in COV: EH cut off valve (3). Pilot pressure to the PVE solenoid valve bridge (7) is interrupted. OSP steering is possible, due to RSV: Reaction Switch Valve (1) stays in normal open position.

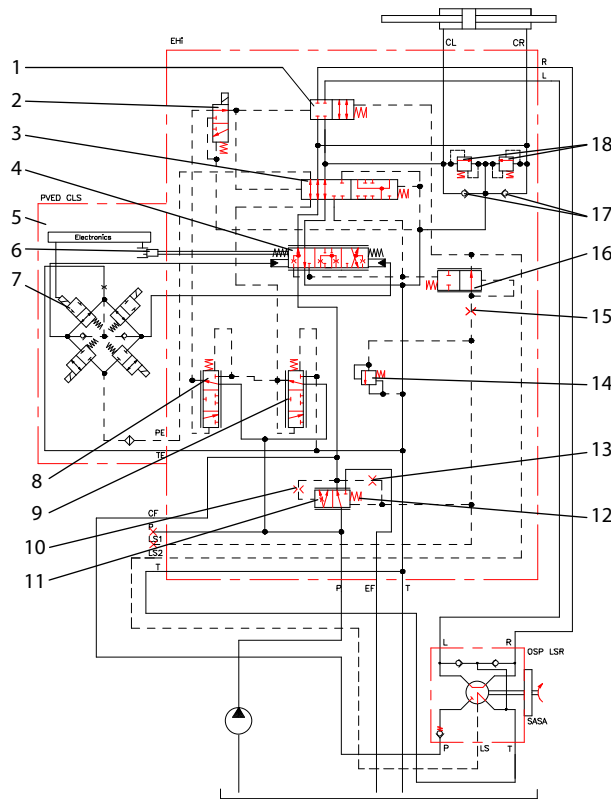
For any steering system that includes a steering unit OSP and EHi valve with Reaction Switch Valve (RSV), it is important that EHi and OSP share the same tank pressure. For this purpose, the EHi provides two tank ports, one of which is intended for connection to the OSP steering unit.

Caution

Loss of EH steering or for reaction systems, an unintended turning of the steering wheel. In load sense systems, the LS to T pressure, and in open center systems the P to T pressure drop in the steering unit should not exceed 14 bar when the steering unit is in neutral position.

Function

Steering Right with EHi



twm1483978840657

1.	RSV: Reaction Switch Valve	10.	PP damping orifice
2.	SOL: Solenoid control valve for EH cut off valve and RSV	11.	Priority valve spool
3.	COV: EH cut off valve	12.	Priority valve spring
4.	EH directional valve	13.	Dynamic orifice
5.	PVE control unit	14.	Pilot pressure relief valve
6.	Spool position sensor LVDT	15.	LS orifice
7.	Solenoid valve bridge	16.	PVFC valve/LS resolver
8.	Pilot reduction valve, 13 bar, SOL-PE	17.	Suction valves
9.	Pilot reduction valve, 13 bar, PE-T	18.	Shock valves

This EHi valve has two pilot reduction valves, PRV's: (8) and (9):

- PRV (9) gives pilot supply, 13 bar above tank pressure to the PVE (5), when the EH cut off valve, COV (3) is activated
- PRV (8) gives pilot pressure, up to 13 bar above PVE pilot pressure (in total up to 26 bar above tank pressure) to activate the reaction switch valve, RSV (1), and to activate COV (3), when the solenoid valve SOL (2) is activated.

Before it is possible to steer with the EHi valve, it is needed to power the solenoid valve (2). When having PVED CLS (5) on the EHi, the CLS controls the SOL (2). The CLS must receive an input from a MMI (Man Machine Interface) to provide EH steering and the CLS will power the SOL (2).

When RSV (1) is activated, Reaction feature of the LSR type steering unit is blocked, the steering wheel will stay in fixed position independent of cylinder port pressures.

Function

When an input signal for steering is transmitted to the electrical connectors of the PVE (5), in this example to steer to the right, the solenoid valve bridge (7) is activated, and the EH directional spool (4) is moved to the right. So LS in spool (4) will sense the needed steering pressure, and this is transmitted to the PVFC valve/LS resolver (16). So the valve (16) makes restriction in the dynamic LS flow from dynamic orifice (13) of priority valve, and the LS pressure on the priority valve spool (11) will match the LS pressure required from the EH directional valve spool (4). Accordingly, the position of the priority valve spool (11) will change to match the flow and pressure demand for EH-steering.

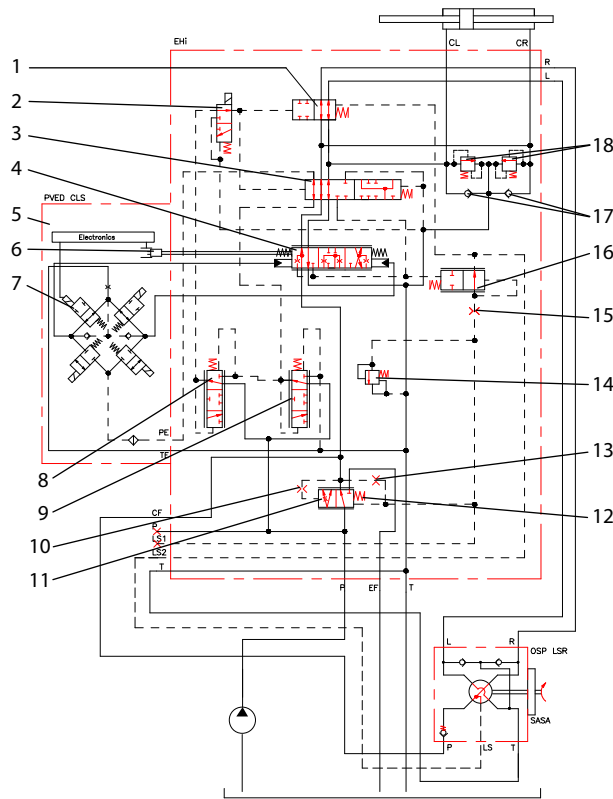
In case the monitoring part of the PVED CLS registers an unintended EH directional spool movement, the electrical power to the SOL (2) will be switched off.

So valve (8 and 9) will dump pilot pressure to tank, COV (3) will change position so that connection from EH directional valve spool (4) to cylinder ports will be blocked. Furthermore, it will not be possible to activate the solenoid valve bridge (7) of PVE without pilot pressure. RSV (1) also change position to open connection between L and R of OSP to the cylinder ports CL and CR.

In any steering scenario, manual steering wheel steering can override the EH steering: by turning the steering wheel, the steering wheel sensor type SASA transmits signal to the PVED CLS and the EH steering will disengage to give steering wheel priority. Furthermore, LS pressure from OSP steering unit will increase, and this pressure will be transmitted to port LS2 of EHi and on to the RSV (1) and this will open for steering wheel steering.

Function

Steering Right with EHi and OSP: variable steer mode



vht1483980855471

1.	RSV: Reaction Switch Valve	10.	PP damping orifice
2.	SOL: Solenoid control valve for EH cut off valve and RSV	11.	Priority valve spool
3.	COV: EH cut off valve	12.	Priority valve spring
4.	EH directional valve	13.	Dynamic orifice
5.	PVE control unit	14.	Pilot pressure relief valve
6.	Spool position sensor LVDT	15.	LS orifice
7.	Solenoid valve bridge	16.	PVFC valve/LS resolver
8.	Pilot reduction valve, 13 bar, SOL-PE	17.	Suction valves
9.	Pilot reduction valve, 13 bar, PE-T	18.	Shock valves

For this variable steering ratio/combined steering mode: EHi + OSP, the CLS must receive an input from a MMI (Man Machine Interface) to allow EH and OSP steering in combination: The SASA signal will be used to add EH flow to the OSP steering as function of steering wheel speed. The LS pressure from OSP will be transmitted to the LS2 port of the EHi, and on to the RSV (1), so that this will stay in open position during steering wheel steering. At the same time the PVED CLS (5) will receive a signal to add EH flow to the OSP flow. So the number of turns on the steering wheel moving the steered wheels from the one to the other lock will be reduced dependent on parameter setting of the PVED CLS.

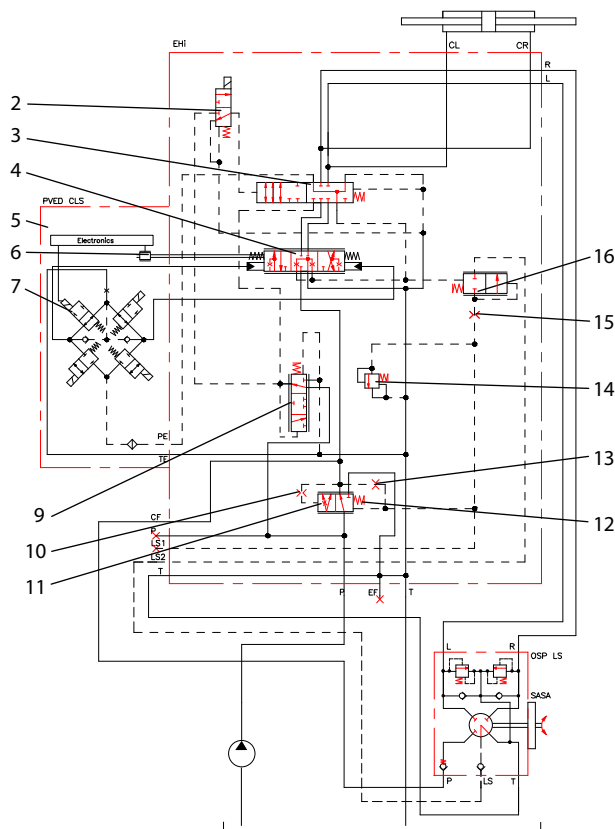
Function

EHi xx LD N E for None Reaction type steering unit

EHi for Load Sensing Dynamic none reaction OSP Steering unit, electrical disengage of EHi by SASA Steering Wheel Sensor. This EHi version has less valve functions than EHi for Reaction type steering unit, described [EHi xx LD R E for Reaction type steering unit](#) on page 14. When the none reaction type steering unit has integrated shock and suction valves, these valve functions are not needed inside the EHi valve. With no reaction switch valve (RSV) it is not needed to have high pilot pressure, therefore only one pilot reduction valve is present.

Configuration number: EHi-4

Neutral position



2.	SOL: Solenoid control valve for EH cut off valve	10.	PP damping orifice
3.	COV: EH cut off valve	11.	Priority valve spool
4.	EH directional valve	12.	Priority valve spring
5.	PVE control unit	13.	Dynamic orifice
6.	Spool position sensor LVDT	14.	Pilot pressure relief valve
7.	Solenoid valve bridge	15.	LS orifice
9.	Pilot reduction valve, 13 bar, PE-T	16.	PVFC valve/LS resolver

When the engine is turned off, the priority valve spool (11) is pushed to the left by the spring (12). The passage to the EF port is blocked. The passage to the EH directional valve spool (4) and to the CF port of EHi is open. The P-port of the OSP LS steering unit is connected to CF port of EHi.

When the engine is on and the steering unit OSP and the EH spool (4) is in neutral position, the CF pressure will rise to match the spring force in the priority valve, consequently the priority valve spool (11)

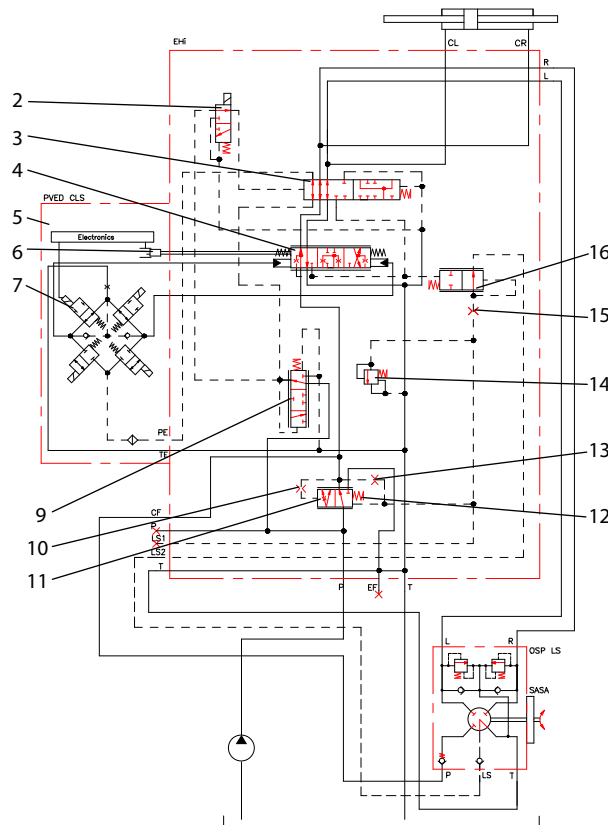
Function

will move to the right and the main pump flow will pass from P port of EHi across the integrated priority valve spool (11) and out through the EF port.

The priority valve is a “dynamic” type, meaning, when pump is on, a minor oil flow passes from CF through the Dynamic orifice (13) (integrated in spool 11), the LS orifice (15), the PVFC valve (16), out of LS2 port of EHi and into the LS port of the OSP steering unit. In OSP the flow in LS line streams across the LS check valve and into the spool/sleeve set and in neutral position this dynamic oil flow passes on to tank.

When the solenoid control valve (2) is deactivated, the EH cut off valve (3) makes unintended EH steering impossible, if for example, a false input signal comes to the PVE control unit (5), because CL and CR connections from EH directional valve spool (4) are blocked in (3).

Steering Right with EHi



2.	SOL: Solenoid control valve for EH cut off valve	10.	PP damping orifice
3.	COV: EH cut off valve	11.	Priority valve spool
4.	EH directional valve	12.	Priority valve spring
5.	PVE control unit	13.	Dynamic orifice
6.	Spool position sensor LVDT	14.	Pilot pressure relief valve
7.	Solenoid valve bridge	15.	LS orifice
9.	Pilot reduction valve, 13 bar, PE-T	16.	PVFC valve/LS resolver

Before it is possible to steer with the EHi valve, it is needed to power the solenoid valve, SOL (2). When having PVED CLS (5) on the EHi, the CLS controls the SOL (2). The CLS must receive an input from a MMI (Man Machine Interface) to provide EH steering and the CLS will power the SOL (2). When SOL is

Function

activated, the EH cut off valve, COV (3) will be moved and pilot pressure from pilot reduction valve, PRV (9) gives pilot supply to the PVE (5) and COV opens for EH steering.

When an input signal for steering is transmitted to the electrical connectors of the PVE (5), in this example to steer to the right, the solenoid valve bridge (7) is activated, and the EH directional spool (4) is moved to the right. So LS in spool (4) will sense the needed steering pressure, and this is transmitted to the PVFC valve/LS resolver (16). So the valve (16) makes restriction in the dynamic LS flow from dynamic orifice (13) of priority valve, and the LS pressure on the priority valve spool (11) will match the LS pressure required from the EH directional valve spool (4). Accordingly, the position of the priority valve spool (11) will change to match the flow and pressure demand for EH-steering.

In case the monitoring part of the PVED CLS registers an unintended EH directional spool movement, the electrical power to the SOL (2) will be switched off. So valve (9) will dump pilot pressure to tank, COV (3) will change position, then connection from EH directional valve spool (4) to cylinder ports will be blocked, and EH steering stops.

In any steering scenario, manual steering wheel steering can override the EH steering: by turning the steering wheel, the steering wheel sensor type SASA transmits signal to the PVED CLS and the EH steering will disengage to give steering wheel priority.

Variable steering ratio/Combined steering mode, EHi + OSP is also possible (not illustrated as diagram): The CLS must receive an input from a MMI (Man Machine Interface) to allow EH and OSP steering in combination: The SASA signal will be used to add EH flow to the OSP steering as function of steering wheel speed. So the number of turns on the steering wheel moving the steered wheels from the one to the other lock will be reduced dependent on parameter setting of the PVED CLS.

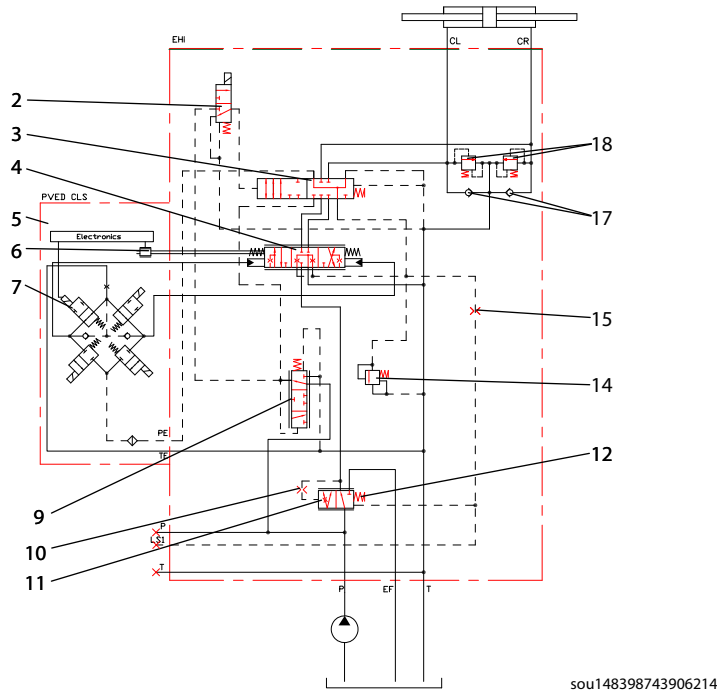
Function

EHi xx W1 N for Steer by Wire steering

EHi Load Sensing Static steering valve for fail-safe Steer by wire Steering. EHi only can be disengaged by removing electric power to solenoid valve.

Configuration number: EHi-7

Neutral position



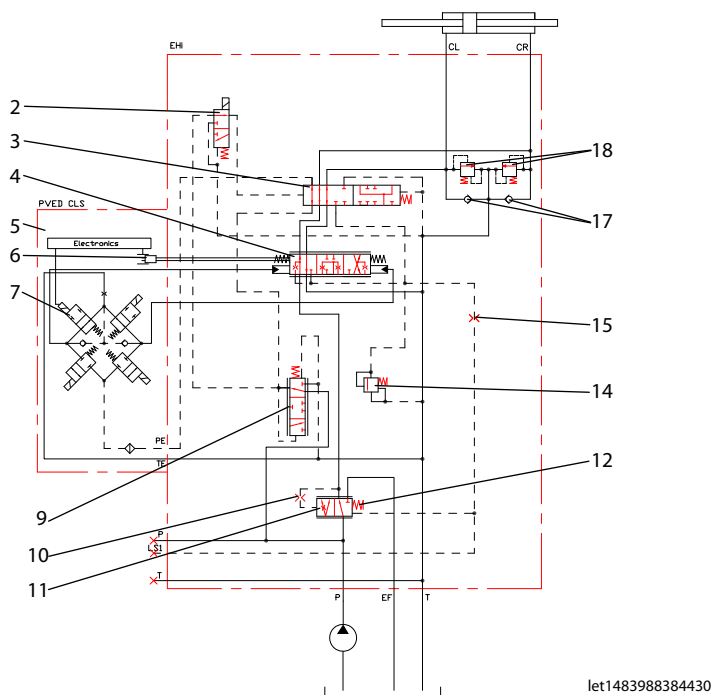
2.	SOL: Solenoid control valve for EH cut off valve	10.	PP damping orifice
3.	COV: EH cut off valve	11.	Priority valve spool
4.	EH directional valve	12.	Priority valve spring
5.	PVE control unit	14.	Pilot pressure relief valve
6.	Spool position sensor LVDT	15.	LS orifice
7.	Solenoid valve bridge	17.	Suction valve
9.	Pilot reduction valve, 13 bar, PE-T	18.	Shock valves

When the engine is turned off, the priority valve spool (11) is pushed to the left by the spring (12). The passage to the EF port is blocked. The passage to the EH directional valve spool (4) is open. When the engine is on and the EH spool (4) is in neutral position, the CF pressure will rise to match the spring force in the priority valve, consequently the priority valve spool (11) will move to the right and the main pump flow will pass from P port of EHi across the integrated priority valve spool (11) and out through the EF port.

When the solenoid control valve (2) is deactivated, the EH cut off valve (3) will prevent unintended EH steering, because CL and CR connections from EH directional valve spool (4) are blocked in (3). Pilot pressure to the PVE solenoid valve bridge (7) is interrupted.

Function

Steering Right with EHi



2.	SOL: Solenoid control valve for EH cut off valve	10.	PP damping orifice
3.	COV: EH cut off valve	11.	Priority valve spool
4.	EH directional valve	12.	Priority valve spring
5.	PVE control unit	14.	Pilot pressure relief valve
6.	Spool position sensor LVDT	15.	LS orifice
7.	Solenoid valve bridge	17.	Suction valve
9.	Pilot reduction valve, 13 bar, PE-T	18.	Shock valves

Before it is possible to steer with the EHi valve, it is needed to power the solenoid valve, SOL (2). When having PVED CLS (5) on the EHi, the CLS controls the SOL (2). The CLS must receive an input from a MMI (Man Machine Interface) to provide EH steering and the CLS will power the SOL (2). When SOL is activated, the EH cut off valve, COV (3) will be moved and pilot pressure from pilot reduction valve, PRV (9) gives pilot supply to the PVE (5) and COV opens for EH steering. When an input signal for steering is transmitted to the electrical connectors of the PVE (5), in this example to steer to the right, the solenoid valve bridge (7) is activated, and the EH directional spool (4) is moved to the right. So LS in spool (4) will sense the needed steering pressure, and this is transmitted on to the priority valve spool (11). Accordingly, the position of the priority valve spool (11) will change to match the flow and pressure demand for EH-steering.

In case the monitoring part of the PVED CLS registers an unintended EH directional spool movement, the electrical power to the SOL (2) will be switched off. So valve (9) will dump pilot pressure to tank, COV (3) will change position, then connection from EH directional valve spool (4) to cylinder ports will be blocked, and EH steering stops.

Technical data

EHi

The technical data for EHi are typical measured results. For the hydraulic system a mineral based hydraulic oil with a viscosity of 21 mm²/s (102 SUS) and a temperature of 50° C (122° F) was used.

Max. pressure	Port P-T, EF-T	250 bar	[3625 psi]
	Port CF-T	210 bar	[3045 psi]
	Port LS1-T, LS2-T	210 bar	[3045 psi]
	Port L-T, R-T, CL-T, CR-T	280 bar	[4060 psi]
	Port T	25 bar	[362 psi]
Oil flow rated	Port P, EF	90 l/min	[23.8 US gal/min]
	Port L, R, CL, CR steering wheel steering	70 l/min	[18.5 US gal/min]
	Port CL, CR EH steering	12, 20, 30, 40, 50 or 70 l/min	[3.2, 5.3, 7.9, 10.6, 13.2 or 18.5 US gal/min]
Spool travel, EH directional spool		± 4 mm	[± 0.16 in]
Dead band, EH-directional spool, nominal		± 0.8 mm	[± 0.03 in]
Priority valve	Type	Dynamic or Static	
	Spring force	7 bar, 10 bar	[100 psi, 145 psi]
	Nominal flow	45 or 90 l/min	11.9 or [23.8 US gal/min]
Oil temperature	Recommended temperature	+30° C to +60° C	[+86° F to +140° F]
	Min. temperature	-30° C	[-22° F]
	Max. temperature	90° C	[190° F]
Ambient temperature		-30° C to +60° C	[+22° F to +140° F]
Oil viscosity	Operating range	12 to 75 mm ² /sec	[66.0 to 370.3 SUS]
	Min. viscosity	10 mm ² /sec	[58.9 SUS]
	Max. viscosity	460 mm ² /sec	[2134 SUS]
Filtration	Max contamination (ISO 4406)	21/19/16	
Temperature difference between steering valve and other hydraulics	Max.	10° C	[50° F]

Weight

EHi weighs 11.2 kg (24.7 lbs).

PVE actuation modules

PVE actuation modules comprehensive technical literature

PVED-CLS	<i>OSPE with PVED-CLS Steering Valve Controller Data Sheet</i>	L1309911
PVED-CC Series 5	<i>PVED-CC Series 5 Technical Information</i>	BC00000322
PVES Series 7	<i>PVE Series 7 Technical Information</i>	BC00000378

Comprehensive technical literature is online at powersolutions.danfoss.com

Technical data

PVE actuation modules main values

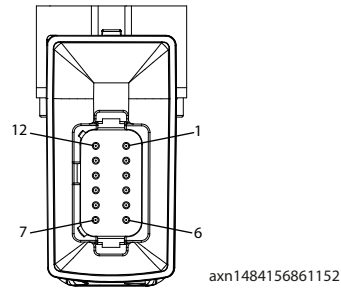
		PVED CLS	PVED CC	PVES
Supply voltage		9 to 35 Vdc		11 to 32 Vdc
Current consumption	in operational/off-road mode, activating cut off valve, max	1.32 A at 12 V	-	-
	in on-road mode	0.23 A at 12 V	-	-
	in operational mode	-	0.52 A at 12 V	-
	in neutral – Power state	-	0.08 A at 12 V	-
	at rated voltage PVES	-	-	0.57 A at 12 V
Signal voltage	neutral	-	-	0.5 x U DC
	CR-port ↔ CL-port	-	-	0.25 · U DC to 0.75 · U DC
Signal current at rated voltage		-	-	0.25 mA to 0.70 mA
Oil consumption	Electrical de-energized	0 l/min	0 l/min	0.3 l/min
	Spool locked position	0 l/min	0 l/min	0.1 l/min
	Pilot oil flow, continuous actuations	0.7 l/min	0.7 l/min	0.8 l/min
Oil viscosity	range	12 to 75 mm ² /s		
	min.	10 mm ² /s		
	max.	460 mm ² /s		
Oil temperature	Rec. range	+30° C to +60° C (+86° F to +140° F)		
	min.	-30° C (+22° F)		
	max.	90° C (194° F)		
Ambient temperature	Rec. range	-30° C to +60° C (+22° F to +140° F)		
Filtering		Max. allowed degree of contamination (ISO 4406): 23/19/16		
Pilot pressure	Rec. range	13.5 ± 1.5 bar		
Hysteresis		approx. 0%		
Enclosure	DEUTSCH connector	IP 67		
Pins, surface treatment	DEUTSCH connector	Sn/Tin		Ni/Nickel

Technical data

PVE connectors

PVED-CLS

DEUTSCH one 12 pin connector - DT04-12PA-B016



Pinouts

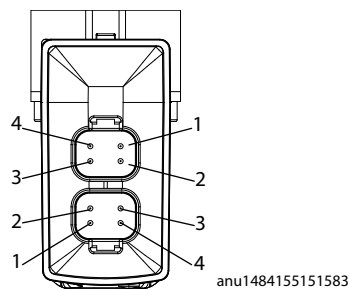
Pinout	Function	Pinout	Function
1	AD2	7	Power ground -
2	AD3	8	Power supply +
3	Sensor power ground	9	CAN_L_MAIN
4	CAN_H_SAFETY	10	CAN_H_MAIN
5	CAN_L_SAFETY	11	5V sensor supply+
6	Digital output	12	AD1

Terminator resistor: None

Mating connector: DT06-12SA-P012

PVED-CC Series 5

DEUTSCH DT - two 4 pin connector, DT04-4P



Pinouts

Pinout	Function	Pinout	Function
Front		Back	
1	CAN_H	1	CAN_H
2	CAN_L	2	CAN_L
3	Power supply +	3	Power supply +
4	Power ground -	4	Power ground -

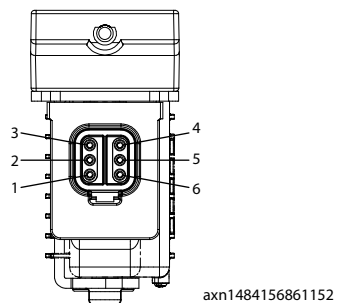
Terminator resistor: None

Mating connector: DT06-4S-E003

Technical data

PVES-SP Series 7

DEUTSCH DT - one 6 pin connector, DT04-6P



Pinouts

Pinout	Function	Pinout	Function
1	Vsignal	4	Spool position
2	Error	5	Power ground -
3	not used	6	Power ground +

Mating connector: DT06-6S-E003

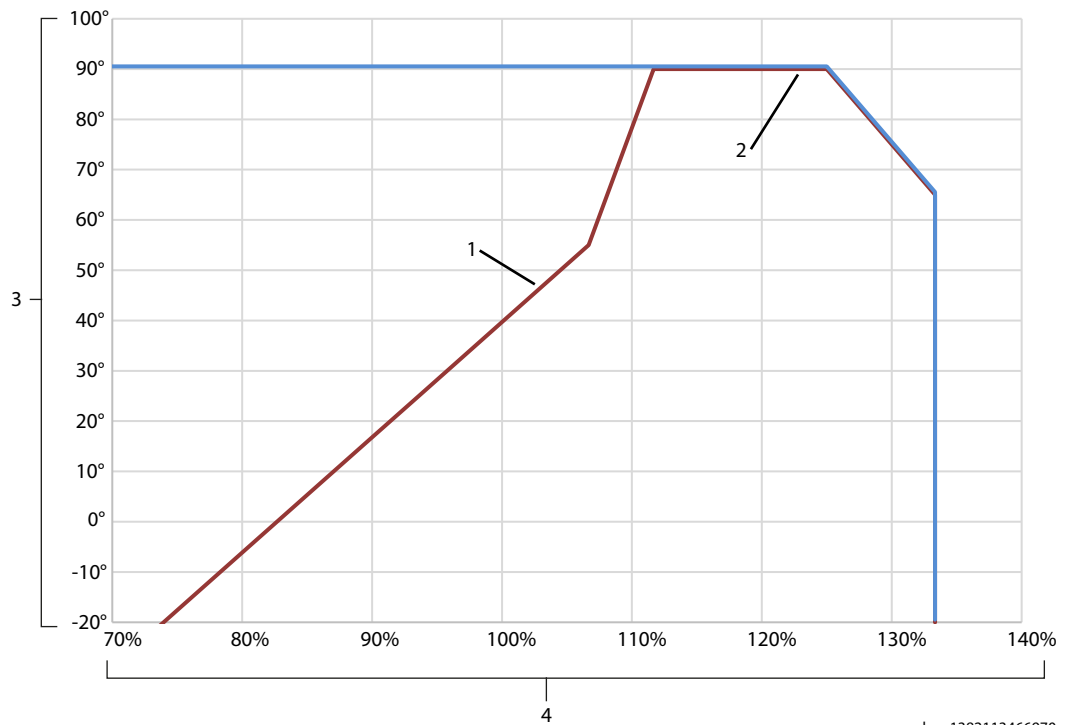
Technical data

Coil of control valve for mode select

Specifications

- Duty cycle rating: 100%
- Magnet wire insulation: Class H (180C)
- Ambient temperature: -30° C to +60° C [-22° F to +140° F]
- Diodes are available; contact your Danfoss representative
- Environmental protection: IP 65
- All AC coils are internally rectified

Operating limits, D08, 16 watt coil



1. Minimum pull-in voltage
2. Maximum operating limit
3. Ambient temperature in Celsius
4. Percent rated voltage

Electrical specifications

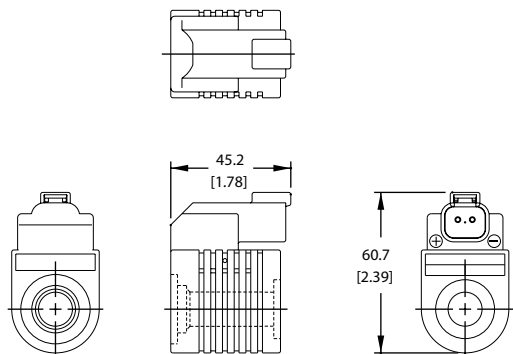
16 watt coils

Voltage (V)	Resistance (Ohms) ±5% at 20° C [72 °F]	Current draw (A) at 25° C [77° F]	Color	Terminals
12	9	1.33	Gray	DEUTSCH
24	36	0.67	Black	DEUTSCH

Technical data

Terminals

DEUTSCH Code DE



kwa1382113478636

Voltage (V)	Power (W)	Part number
12	16	D08-16-12D-DE
24	16	D08-16-24D-DE

Dimensioning steering system

Steering systems with EHi steering valve

Steering systems using an ordinary steering unit (for example, Danfoss OSP type steering unit), for manual steering and an EHi valve for electrical steering (for example, auto guidance, joystick, and/or variable steering), the following main values for EHi must be decided.

- Nominal cylinder port flow, CQ
 - Normally based on port flow available from OSP approximately at 100 rpm steering wheel speed, for example, an OSPC 200, the port flow will be 20 l/min at 100 rpm, so the EH directional spool should be the one with CQ = 20 l/min nominal.
- Maximum steering pressure, bar, P-T
 - Same as the P-T value for the OSP steering unit if a relief valve is present in the OSP, otherwise P-T setting of the EHi must be determined based on maximum steering system pressure allowed.
- Shock valves, whether needed or not
 - If shock valves outside the EHi valve are protecting the cylinder ports of the EHi in any steering mode, no shock valves will be needed inside the EHi valve.
 - If shock valves are needed inside EHi, the setting must be approximately 50 bar higher than maximum steering pressure, P-T.

! Caution

High steering cylinder speed can affect controllability of the vehicle.

Do not choose a directional spool with higher nominal flow than recommended, which can affect requirements for response time of any safety functions added to the steering system.

! Caution

EHi, in connection with OSPD ON/OR, Open center type steering units with dual displacement, system instability can be an issue.

Minimum flow of 5 l/min to the P port of the steering unit must be ensured, so that in any EH steering situation, shift valve in the OSPD steering unit will be in position for normal steer mode/full displacement. Flow to P port of OSPD should not drop below 5 l/min to avoid the shift valve moving to "emergency steer position".

For fail-safe Steer By Wire Steering systems only using EHi valve for the following main values for EHi must be decided.

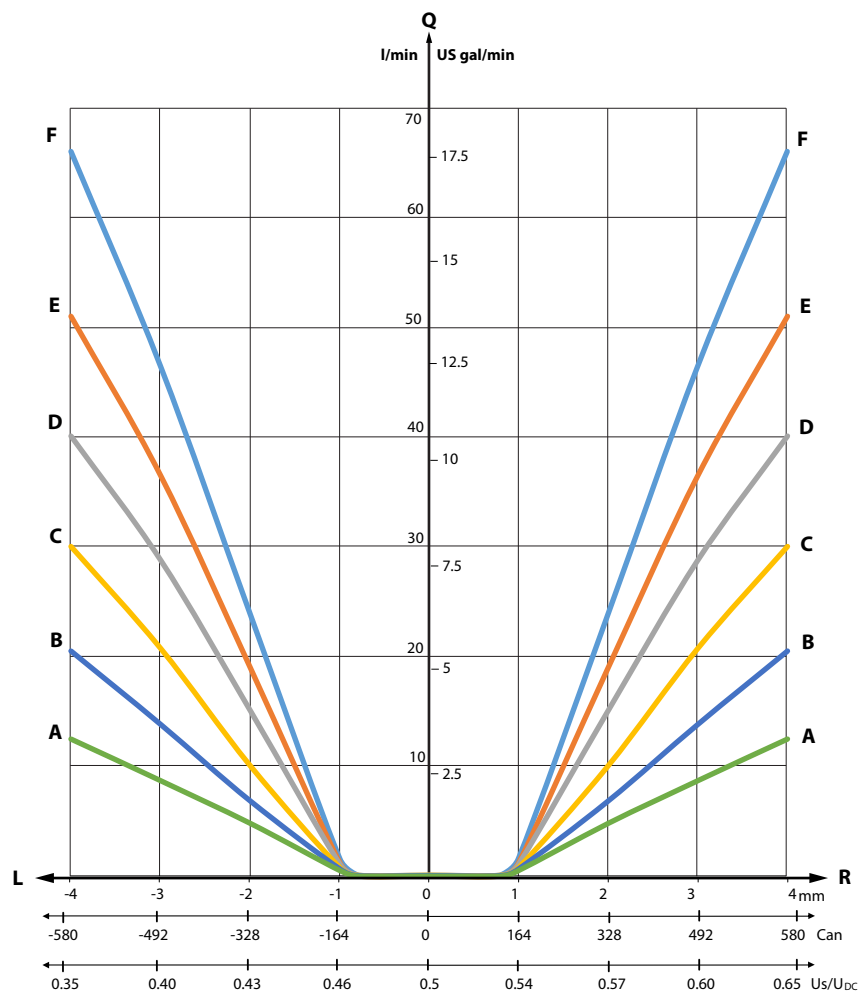
- Nominal cylinder port flow, CQ
 - Normally based on maximum time(s) for turning steered wheels from one to the other cylinder lock, cylinder having stroke volume V
 - V(l) 0,800 l
 - t(s) 2,4 sec
 - = >
 - CQ (l/min) = V/t = (0,8/2,4)*60 = 20 l/min
- Maximum steering pressure, bar, P-T
 - Must be determined based on maximum steering system pressure allowed.
- Shock valve setting
 - Must be approximately 50 bar higher than maximum steering pressure, P-T

For other options to be determined for EHi, see [Versions](#) on page 7.

Technical characteristics

EHi-directional spools of EHi

Cylinder flow characteristic for directional spools



- A** = Valid for spools for nominal cylinder flow CQ = 12 l/min [3.17 US gal/min]
- B** = Valid for spools for nominal cylinder flow CQ = 20 l/min [5.28 US gal/min]
- C** = Valid for spools for nominal cylinder flow CQ = 30 l/min [7.97 US gal/min]
- D** = Valid for spools for nominal cylinder flow CQ = 40 l/min [10.57 US gal/min]
- E** = Valid for spools for nominal cylinder flow CQ = 50 l/min [13.21 US gal/min]
- F** = Valid for spools for nominal cylinder flow CQ = 70 l/min [18.48 US gal/min]

The curves, A through E, are valid for EHi with internal priority valve with 7 bar [100 psi] spring and 0.9 mm [0.035 in] dynamic orifice, and 1.2 mm (0.047 in) LS orifice, and at 60 l/min [15.85 US gal/min] pump flow.

For EHi without internal priority valve, the curves, A through E, are valid in combination with external priority valve OLS 80, 152B8258 at 60 l/min [15.85 US gal/min] pump flow.

The curve F is valid for EHi with internal priority valve with 10 bar [145 psi] spring and 0.9 mm [0.034 in] dynamic orifice and 1.2 mm (0.047 in) LS orifice and at 100 l/min [26.41 US gal/min] pump flow.

Technical characteristics

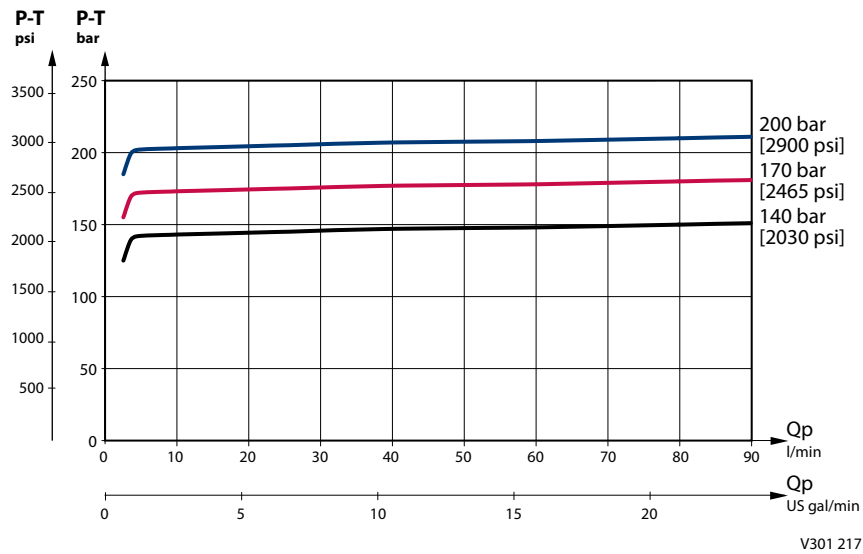
For EHi without internal priority valve, the curves, F is valid in combination with external priority valve OLS 120, 152B8129 at 100 l/min [26.41 US gal/min] pump flow.

Pilot pressure relief valve, (P - T, Qp) characteristic

The pilot pressure relief valve protects the steering system against excessive pressure.

The pilot pressure relief valve works together with the priority valve in the EHi or together with the external priority valve to limit the maximum steering pressure P-T. The pilot pressure relief valve is set at an oil flow to the priority valve of 25 l/min [6.6 US gal/min].

Setting tolerance: rated value +10 bar [145 psi].



EHi's with 45 l/min priority valve spool should not be applied with more than 45 l/min pump flow.

Pressure drop, P-EF for EHi valve

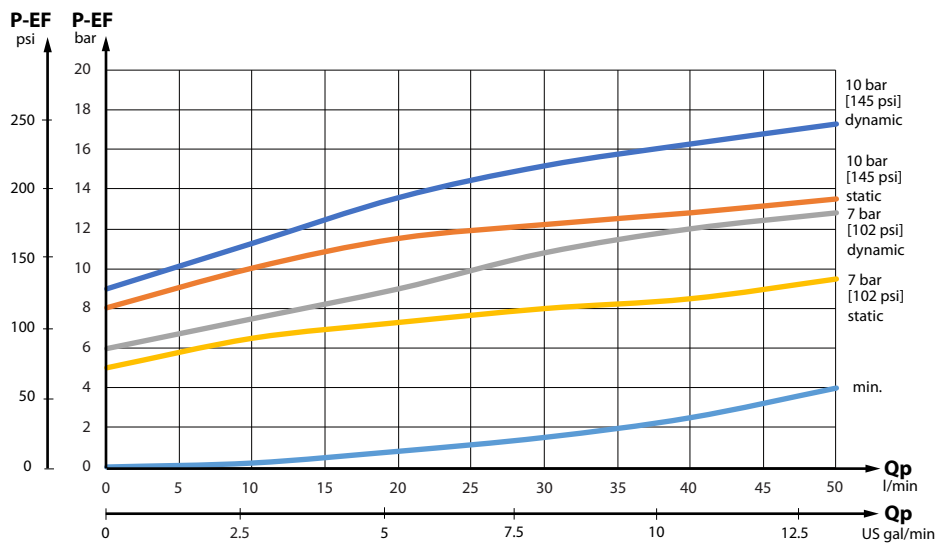
This data comes from measurements on a representative sample of EHi valves from production. Oil with viscosity of 21 mm²/s at 50° C was used during measuring.

Measurement is made when the pressure on the LS connection is zero. The minimum curve applies when the pressure on the EF connection is higher than the actual control spring pressure.

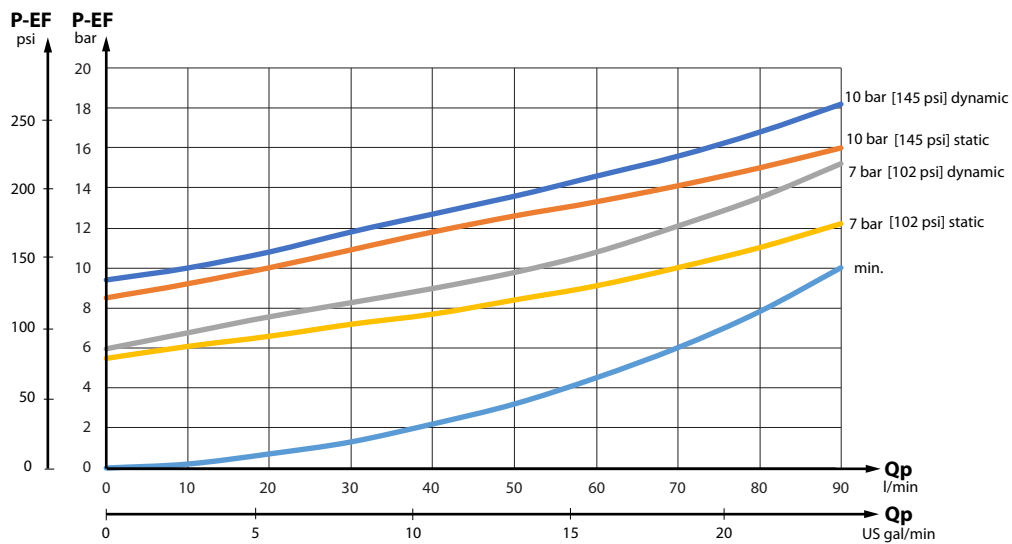
The curve for control spring pressure of 7 bar [100 psi] and 10 bar [145 psi] applies when pressure on the EF port is zero.

Technical characteristics

EHi with 45 l/min priority valve spool



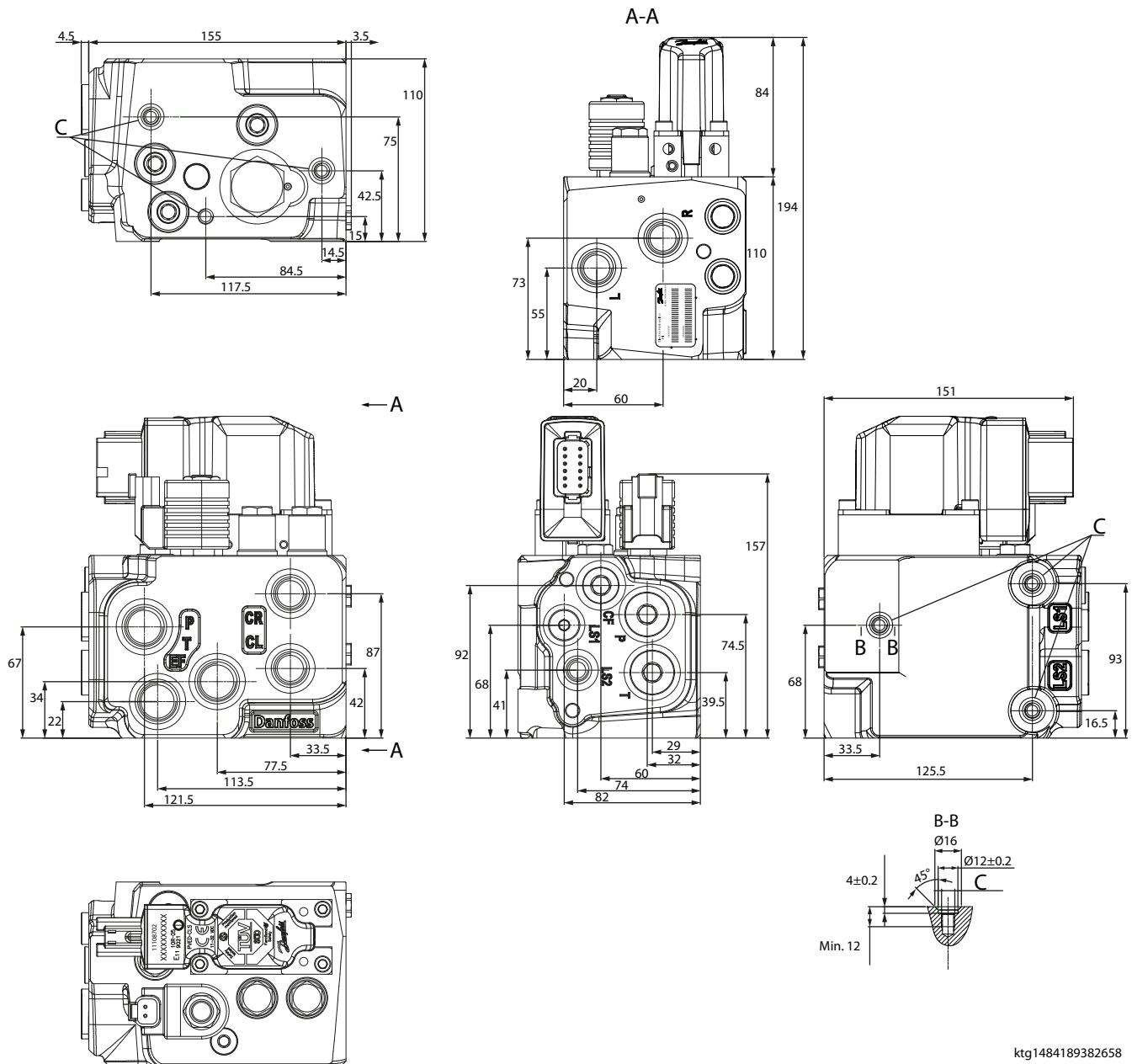
EHi with 90 l/min priority valve spool



Dimensions

EHi with PVED-CLS

Dimensions in millimeters



ktg1484189382658

Metric-port version (ISO 6149-1)

P, T, EF	CL, CR, L, R	LS1, LS2	C
M22 x 1.5 15 mm deep	M18 x 1.5 14.5 mm deep	M12 x 1.5 11.5 mm deep	M8 x 1.25 12 mm deep

System safety

Emergency steering

Steering systems with EHi steering valve and OSP steering unit:

In case of no steering pump supply, the OSP steering unit can be used for emergency steering. The gear wheel set acts as a hand driven pump, and so muscle power will be converted from input torque and rotation on the steering wheel to hydraulic power in the form of pressure and flow out of the cylinder port to which side the steering is done.

Look in *General, Steering Components Technical Information*, **520L0468**, under the General Information chapter, for calculating manual/emergency steering.

For fail-safe Steer By Wire Steering systems only using EHi steering valve, manual activated emergency steering will not be possible. Such steering systems must be set up with complete redundancy, or it must only be used for limited maximum driving speed and only for off road usage.

EHi and system safety

EHi has built in safety function in form of cut off valve. In starting point this cut off valve is in safe state. Connections from directional valve to cylinder ports are blocked. The cut off valve will only make EH steering possible when the solenoid valve is powered.

The cut off valve controls the pilot pressure to the PVE actuator. If there isn't any power on the solenoid valve, there isn't any pilot supply to the PVE to move the directional spool out of neutral.

In addition to electrical control, by means of the solenoid valve, the reaction switch valve (RSV) can be pushed over hydraulically by turning the steering wheel. Through this design, full system pressure is available to force open the RSV.

Disengage is achieved by means of SASA sensor. For EHi configuration numbers EHi-9 and EHi-10, see [EHi standard configurations](#) on page 40. Both RSV and cut off valve (COV) can be pushed over hydraulically by turning the steering wheel. Disengage is achieved by means of EH spool monitoring.

Full system pressure to move spools may be considered a well tried safety principle according to ISO13849-2 annex C, table C.2

PVED CLS actuator works as a certified Safety Controller. The PVED CLS directly controls the cut off valve by power on/power off to the solenoid valve. If there isn't any power on the solenoid valve, the EHi is in *Safe State*.

Integrated safety functions in the PVED-CLS can power off the solenoid valve, and bring the EHi to a safe state. Refer to *PVED-CLS Controller for Electrohydraulic Steering User Manual*, (**official literature number not available at this time**).

PVE actuators PVED CC or PVES, the cut off valve function must be controlled by a separate controller. For example, vehicle main controller, which must power on/power off the solenoid valve to disable/enable *Safe State* of the EHi valve.

Safety considerations, On-road operation

PVED-CC and PVES actuators are single string designs with limited on board fault monitoring.

The OEM is responsible to establish the necessary means to inform and de-energize the PVE from the cabin when driving on public roads.

Caution

Non-conforming steering can affect controllability of the vehicle.

Apply vehicle specific safety monitoring systems that will detect non-conforming steering; issue appropriate warnings; and effectively disable PVED-CC and PVES actuators if necessary. A minimum safety system should include a manual power switch to electrically power off electrohydraulic actuators and the solenoid valves while driving on public roads.

System safety

The PVED-CLS actuator can be de-energized while driving on public roads. A road switch design may be applied, to keep the PVED-CLS energized while driving on public roads. Refer to *PVED-CLS Controller for Electrohydraulic Steering User Manual*, (**official literature number not available at this time**).

Variants and ordering specifications

EHi MMC

Determine Master Model Code (MMC). Fill in with codes from [Variants codes for EHi MMC](#) on page 38, to specify EHi steering valve.

MMC values for EHi steering valve

EHi														
-----	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Example only

EHi ¹	20 ²	LD ³	R ⁴	E ⁵	CLS2D ⁶	12D ⁷	90 ⁸	07 ⁹	M1 ¹⁰	I ¹¹	180 ¹²	240 ¹³	PB ¹⁴
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¹ EH base

² EH spool, l/min

³ Concept

⁴ RSV

⁵ Disengage

⁶ PVE, type. connector

⁷ Coil, Voltage V, connector

⁸ Priority valve l/min. Fill in NN for EH without priority valve.

⁹ Priority valve, spring. Spring force, bar. Fill in NN for EH without priority valve.

¹⁰ Housing

¹¹ Relief valve, connection

¹² Relief valve setting, bar

¹³ Shock valves setting, bar. Fill in NNN for EH without shock and suction valves.

¹⁴ Painting. Fill in NN for unpainted EH.

Code numbers

Configuration numbers, in the following table, are referring to matrix description for [EHi standard configurations](#) on page 40.

Code numbers for catalog versions with specifications

Code no.	Config. no.	MMC-specifications according to above description format												
11179597	EHi-1	30	LD	N	E	CLS2D	12D	NN	NN	M1	I	175	NNN	PB
11179598	EHi-2	30	OC	N	E	CLS2D	12D	90	10	M1	I	175	NNN	PB
11179600	EHi-4	30	LD	N	E	CLS2D	12D	90	07	M1	I	175	NNN	PB
11179613	EHi-5	30	LD	R	E	CLS2D	12D	90	07	M1	I	175	230	PB
11179614	EHi-6	30	LD	R	E	CLS2D	12D	NN	NN	M1	I	175	230	PB
11179601	EHi-7	30	W1	N	N	CLS2D	12D	90	10	M1	I	175	230	PB
11179612	EHi-8	30	W2	N	N	CLS2D	12D	90	10	M1	I	175	230	PB

Variants and ordering specifications

Variants codes for EHi MMC

1) EH base

EHi	Single section Electrohydraulic steering valve
Code	EHi

2) EH spool, l/min

Cylinder flow, nominal, l/min	12	20	30	40	50	70
Code	12	20	30	40	50	70

3) Concept

Steering unit type Or Steer by Wire	Open center	Closed center	LS dynamic	LS static	LS dynamic and static*	Steer by Wire 1**	Steer by Wire 2***
Code	OC	CC	LD	LS	LC	W1	W2

* EHi is configured for both Dynamic and Static priority valve.

** For single EHi in Steer by Wire system or for the second EHi in Steer by Wire system with two EHi's.

*** For the first EHi in Steer by Wire system with two EHi's.

4) RSV

Reaction Switch Valve, RSV*	Not included	Included
Code	N	R

* Reaction Switch Valve (RSV) only needed in connection with Reaction type steering units.

5) Disengage

How to override EH steering	With steering unit		Steer by wire: Not relevant
	Electric signal, from, for example, SASA sensor	Hydraulic override from steering unit	
Code	E	H	N

6) PVE, type - connector

Type Connector	PVED CLS SIL 2 DEUTSCH, one 12 pin	PVED CC DEUTSCH, two 4 pin	PVES DEUTSCH, one 6 pin
Code	CLS2D	PVCCD	PVESD

7) Coil, Voltage V, connector

Voltage, V Connector*	12 DEUTSCH, one 2 pin	24 DEUTSCH, one 2 pin
Code	12D	24D

* For CLS actuator, which controls the coil: always use 12 V coil.

8) Priority valve l/min

For pump flow, nominal, l/min	45	90	None if priority valve is not needed inside EH
Code	45	90	NN

Variants and ordering specifications

9) Priority valve, spring, Spring force, bar

Spring force, bar (for any spool)*	7	10	None if priority valve is not needed inside EH
Code	07	10	NN

* Priority valve spring, standard: For LS dynamic systems: 7 bar. For LS static systems: 10 bar.

10) Housing

Thread*	M1: Metric, ISO 6149-1
Code	M1

* See following table regarding Housing threads.

Housing threads

	P, P2, T, T2, EF	CL, CR, L, R, CF	LS1, LS2
Metric, ISO 6149-1	M 22 x 1.5 – O* + S**	M 18 x 1.5 – O* + S**	M 12 x 1.5 – O* + S**

* O-ring chamfer on port connection.

** Spot face around port connection.

11) Relief valve, connection

Connection inside EH	In LS line for EH spool (when a relief valve also is present inside the steering unit)	In LS line for priority valve (when no relief valve is present in the steering unit)
Code	I	O

12) Relief valve setting, bar

P-T, bar *	110 to 210
Code	P-T value, bar, for example, 180

* Tolerance: +10 bar independent on setting value

13) Shock valves setting, bar

R-T/L-T, bar*	160	175	190	210	230	240	250	265	280	None
Code	160	175	190	210	230	240	250	265	280	NNN

* Shock valves only available with fixed nominal min. setting as stated. Tolerance: +23 bar up to 230 bar nominal. +10% from 240 bar nominal.

14) Painting

Painting	Unit painted black (standard)	Unit not painted (option)
Code	PB	NN

Variants and ordering specifications

EHi standard configurations

Configurations	OEM installation						SBW / 4WS	4WS	GPS Universal	
	EHi-1	EHi-2	EHi-3*	EHi-4	EHi-5	EHi-6	EHi-7	EHi-8	EHi-9*	EHi-10*
<i>Hydraulic Circuit</i>	Load Sensing	Open Center	Closed Center	Load Sensing	Load Sensing Reaction	Load Sensing Reaction	SBW fail-safe / 4 Wheel Steering	4 Wheel Steering	Load Sensing (Static and Dynamic) With/Without Reaction	Open Center With/Without Reaction
<i>Feature</i>										
EH w. PVES, D CC, CLS	•	•	•	•	•	•	•	•	•	•
Cut-off valve	•	•	•	•	•	•	•	•	•	•
Relief valve	•	•	•	•	•	•	•	•	•	•
Priority valve		•	•	•	•		•	•		•
Shock-suction valves					•	•	•	•	•	•
PVFC LS resolver valve	•			•	•	•			•	•
Reaction Switch Valve for reaction (RSV)					•	•			•	•
OSP override on RSV					•	•			•	•
LS shuttle (SBW or 2WS)								•		
EF and T internally connected				•						
Disengage without SASA (hydraulic disengage)**									•	•
Electrical disengage, for example, by SASA	•	•	•	•	•	•	•	•		

* Contact Danfoss Power Solutions for information.

** Variable steer mode is not available when using hydraulic disengage.

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