

Technical Information

Electrohydraulic Steering

PVED-CLS Controller



Revision history*Table of revisions*

Date	Changed	Rev
September 2020	Changed document number from 'BC00000355' to 'BC183186484596' and updated EMC and Rohs directive	0206
March 2017	pg 6 minor edit Power supply +	0104
September 2016	Updated functional safety information	0103
June 2016	Added link to errata information	0102
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Introduction

Purpose of the document

This document describes the electrical technical specifications of the PVED-CLS and steering valve.

Errata information

Errata information is available at:

www.danfoss.com

Errata information is available for the following:

- PVED-CLS bootloader
- PVED-CLS application
- Documentation
- PLUS+1® Service Tool
- Other topics related to the steering system

If additional information is needed, contact your Danfoss product application engineer.

The system integrator who is responsible for the target system is advised to periodically observe the errata information because new information will be added as needed.

References

Literature	Type	Reference number
OSPE Steering valve, SASA sensor	Technical Information	11068682
PVED-CLS KWP2000	Protocol	L1412764
EHPS Steering Valve, PVE Actuation, OSPCX CN Steering Unit	Technical Information	520I0521
EHi Steering Valve	Technical Information	BC220386485094

Definitions and Abbreviations

AD	Analogue Digital
AgPL	Agricultural Performance Level
CAN	Controller Area Network
COV	Cut-off Valve
DC	Diagnostic Coverage
DOUT	Digital Output
EHi-E	Electro Hydraulic inline valve - Electronic disengage
EHi-H	Electro Hydraulic inline valve - Hydraulic disengage
EHPS	Electro-Hydraulic Power Steering
HFT	Hardware Failure Tolerance
OSPE	Orbital Steering Product – Electro-hydraulic
PAE	Product Application Engineering
PFH	PFHd, Probability of Dangerous Failure [1/h]
PL	Performance Level
PVED-CLS	Proportional Valve Digital – Closed Loop - Safety (valve controller)
PWM	Pulse Width Modulation
SFF	Safe Failure Fraction

Introduction

SIL	Safety Integrity Level
SRL	Software Requirement Level
VDC	Voltage Direct Current

Product Overview

Description	Comment
PVED-CLS part number	11108702, 11164272, 11187654, 11187653
PVED-CLS label, engraving	Part number, production cell number, manufacturing date, week, year, day, serial number, nominal supply voltage range, E-mark, TÜV certificate

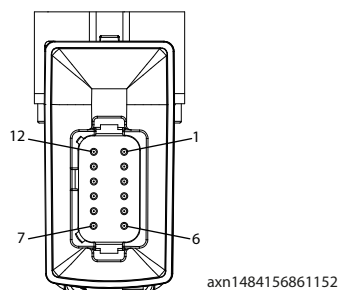
PVED-CLS, part number 11018702



Connector interface

The PVED-CLS will only be available with one connector variant: 12 pin DEUTSCH DT04-12PA-B016 connector.

PVED-CLS DEUTSCH connector



- | | |
|--|-------------------------------|
| 1. AD2 | 7. Ground |
| 2. AD3 | 8. Battery supply |
| 3. Sensor power ground | 9. CAN Low, main controller |
| 4. CAN High, safety controller | 10. CAN High, main controller |
| 5. CAN Low, safety controller | 11. 5V sensor supply |
| 6. Digital output, high side switch output | 12. AD1 input |

DEUTSCH assembly and installation guidelines must be observed for connector and harness. Danfoss recommends the use of lubricant (such as Nyogel 760G) on low-voltage electrical connector contacts to further enhance the robustness against wear (such as fretting corrosion). Severe and critical vibrations can affect the lifetime of the connector and should be avoided.

Technical Data

The technical data are from typical test 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] were used.

Hydraulic Specifications (OSPE & EHI-E/EHI-H valve)

Description	Min.	Max.	Unit	Comment
Valve spool stroke	-4	4	mm	Nominal stroke
Spool delay time	20	30	ms	Time from applying set-point to spool has moved 3% towards set-point
Valve spool rise time	60	120	ms	Time to stroke spool from 0 to 3.8mm (excluding dead-time)
Valve spool return to neutral (solenoid valve bridge active)	40	80	ms	Spring return and pilot pressure available
Valve spool return to neutral (solenoid valve bridge OFF)		100	ms	Mechanical spring return function
Hysteresis (spool control)	-	-	%	Typically 1-2%. Average value measured at 15%, 50% and 85% spool stroke
Bandwidth (spool control)	-	-	Hz	Typical F3db point at 8-9 Hz @2.0mm spool stroke amplitude
Cut-off valve spool return to closed position		60	ms	Typical time from de-energizing the cut-off solenoid valve to cut-off valve spool block port flows

Hydraulic specifications (EHPS valve)

Description	Min.	Max.	Unit	Comment
Valve spool stroke	-7	7	mm	Nominal stroke
Spool delay time	20	30	ms	Time from applying set-point to spool has moved 3% towards set-point
Valve spool rise time	130	150	ms	Time to stroke spool from 0 to 6.65mm (excluding dead-time)
Valve spool return to neutral (solenoid valve bridge active)	60	120	ms	Spring return and pilot pressure available
Valve spool return to neutral (solenoid valve bridge OFF)		120	ms	Mechanical spring return function
Hysteresis (spool control)	-	-	%	Typically 0.7%. Average value measured at 15%, 50% and 85% spool stroke
Bandwidth (spool control)	-	-	Hz	Typical F3db point at 4-5 Hz @3.5mm spool stroke amplitude

Inputs/Outputs Type and Specifications

Analog inputs (AD1, AD2, AD3)

General

Description	Comment
Response to input below minimum voltage	Non-damaging, non-latching; Reading saturates to the low limit.
Response to input above the maximum voltage	Non-damaging, non-latching; Reading saturates at maximum conversion range.
Response to input open	Input pulled low by 100KΩ pull down resistor
Radiometric measurement (AD1, AD2) (only when using PVED-CLS 5V sensor supply for sensor)	Programmable internal compensation for 5V sensor supply drift and aging. Recommended for sensors without internal regulation capabilities.

Specifications

Description	Min.	Max.	Unit	Comment
Absolute min. and max. allowed voltage at pin	-0	35.5	VDC	Reverse polarity protected
AD input digital conversion range	0	6.0	VDC	
Input impedance	200	250	kΩ	
Analogue low pass filter 3db cut-off frequency	452	512	Hz	Order active hardware filter. AD1/AD2 programmable software low-pass filter (10Hz). AD3 software low-pass filter is fixed to 20Hz.
Sample rate	-	1	ms	Raw sample rate is 1 ms. Control loop uses average of 8 samples.
Precision	-	12	Bit	12 bit ADC

Digital Outputs (PWM, DOUT)

General

Description	Comment
Configuration	High side switch. Sourcing only with current and output state measuring capability.
Over-current protection	Non-damaging. Hard- or soft-reset required.
Short circuit to ground protection	Non-damaging. Hard- or soft reset required.
Short circuit to battery supply protection	Non-damaging. Hard- or soft reset required.
Open circuit detection	Fault detection by software. Programmable. Hard- or soft reset required.
Control modes (application mode)	Closed-loop current control.
Connection monitoring (to load)	Programmable: Sensing current for testing connection to load.
Solenoid valve power save operation	Programmable: 'Pull-in current level + activation' time and 'Hold current level'
Shut-off	Dual processor switch-off controllable.
Fly-back diode (de-energizing inductive load)	Integrated in digital output. No additional diode is required for Danfoss solenoid valves.

Inputs/Outputs Type and Specifications

Specifications

Description	Min.	Max.	Unit	Comment
Output voltage, energized state	Vbat - 1.0	Vbat	VDC	Overall load conditions
Output voltage, off state	0	0.1	VDC	
PWM frequency	284	286	Hz	
Current range	0	2	A	Programmable
Output impedance			Ω	Typically 60mΩ
Over-current detection threshold		2.5	A	
Short circuit to ground protection trip at		4	A	

OSPE Solenoid valve (DO8-16-12D-xx)

Specifications 12V Coil

Below table is only valid when driven with PVED-CLS PWM/DOUT output.

Description	Min.	Max.	Unit	Comment
Time to de-energizing inductive load	40	50	ms	Solenoid valve anchor moves to NC position. Room temperature.
Voltage		12	V	
Resistance			Ω	Typical 9 Ω at 20°C
Current draw		1.33	A	Typical at 20°C

Specifications 24V Coil

Below table is only valid when driven with PVED-CLS PWM/DOUT output.

Description	Min.	Max.	Unit	Comment
Time to de-energizing inductive load	40	50	ms	Solenoid valve anchor moves to NC position. Room temperature.
Voltage		24	V	
Resistance			Ω	Typical 36 Ω at 20°C
Current draw		0.67	A	Typical at 20°C

Inputs/Outputs Type and Specifications**5V Sensor Supply****General**

Description	Comment
Short circuit to ground protection	Non-damaging, output is switched off. Hard- or soft reset required.
Short circuit to battery supply protection	Non-damaging, output is switched off. Hard- or soft reset required.

Specifications

Description	Min.	Max.	Unit	Comment
Sensor output voltage	4.825	5.175	V	5V±5% at maximum current
Monitored sensor output voltage	4.650	5.350	V	Internally monitored by software
Sensor current supply	0	200	mA	Maximum recommended load
Ripple		80	mV	at maximum current







CAN (Controller Area Network)

CAN (Controller Area Network)

Description	Min.	Max.	Unit	Comment
Standard				CAN 2.0B
CAN ports				Two independent CAN ports.
				Main controller CAN port.
				Safety controller CAN port.
Baud rate			Bit/s	250Kbit (J1939, ISO11783)
Termination				No internal termination
Terminating resistance	110	130	Ω	Each end of CAN backbone must be terminated with nominally 120 Ω resistance
CAN bus load		90%	%	Depends on CAN message and update rate configuration

Color/Flash Pattern

LED color/flash pattern indication

LED Color/flash pattern	Indication
 - Orange-Green, flashing	PVED-CLS controllers are in 'boot-loader mode'
 - Orange	PVED-CLS is in initialization or in 'on-road mode'
 - Orange, flashing	PVED-CLS is in safe state, fault code(s) on CAN bus
 - Green	PVED-CLS is in 'off-road mode' or 'service mode'. Main spool in neutral position
 - Green, flashing	PVED-CLS is in 'off-road mode' or 'service mode'. Main spool in flow position range
 - Red	PVED-CLS is in safe state due to internal synchronization fault, lost CAN address arbitration, unable to recover from bus-off state. No fault codes on CAN bus

Flashing frequency is 1Hz. See *PVED-CLS User Manual* **AQ186886485220** for details on operation modes

Technical Information

PVED-CLS Controller for Electrohydraulic Steering

Product Ratings

Power

Description	Min.	Max.	Unit	Comment
Supply voltage range	11	35.5	VDC	
Low supply voltage range	9	11	VDC	Reduced hydraulic performance may occur. No impact on safety integrity
Supply voltage ripple		5	%	
Maximum voltage supply		35.5	VDC	Tolerated for 1 second before fault detection
Supply voltage range for CAN bus communication	5.5	35.5	VDC	Reduced hydraulic performance below 11V. No impact on safety integrity
Power consumption at 12VDC - Boot-loader mode	0.19	0.22	A	All peripherals switched off
	2.28	2.64	W	
Power consumption at 12VDC - On-road mode (OSPE & EHi-E/EHi-H valve)	0.22	0.23	A	COV de-energized, SVB de-energized, electronics powered, 5V sensor load = 200mA
	2.6	2.72	W	
Power consumption at 12VDC - Off-road mode (activating COV) (OSPE & EHi-E/EHi-H valve)	1.20	1.32	A	COV energized (activation phase, activation current set to 1.1A) , SVB energized, electronics powered, 5V sensor load draws 200mA
	14.4	16	W	
Power consumption at 12Vdc - Off-road mode (holding COV state) (OSPE & EHi-E/EHi-H valve)	0.67	0.74	A	COV energized (activation phase, activation current set to 0.5A) , SVB energized, electronics powered, 5V sensor load draws 200mA
	8.0	8.9	W	
PVED-CLS power-up time		2	S	Time from power-on to sending address claim messages. From software version 1.95 robustness against low supply voltage during cranking (Supply voltage < 9V) is implemented, which re-executes the power-on-self-test up to 10 times in case the supply voltage is measured to be below 9V. If such low supply voltage condition occurs during power-up the time to address claim message will increase.

Power consumption specifications assume operation with OSPE/EHi-E/EHi-H solenoid valve.

EEPROM Write/Erase Ratings

Description	Min.	Typical	Max.	Unit	Comment
Erase/Write cycles		>1·10 ⁹			Minimum valid over entire operating temperature range

Product Ratings

Environmental Testing Specifications

The PVED-CLS, solenoid valve and OSPE & EHi-E/EHi-H valve unit has been subject to passing Danfoss 504H0027 environmental test specification and extended environmental test specification as described below.

General Product Ratings

Description	Min.	Max.	Unit	Comment
Ambient temperature (Operational, storage)	-40	110	°C	For operating oil temperature range. See important notes below.
Oil temperature (Operational)	-30	90	°C	For operating ambient temperature range.
Electronics over-temperature shut-down		120	°C	Internal temperature monitoring. Hard- or soft reset required.
Electronics average temperature (life-time)		85	°C	Internal average temperature monitoring. CAN warning.

Important

The PVED-CLS can withstand long-term ambient temperatures at 110°C. The PVED-CLS is designed to shut-off when the electronics temperature exceeds 120°C. Taking electronics self-heating into considerations, Danfoss recommends not exposing the PVED-CLS to steady state ambient temperatures above 85°C.

The PVED-CLS will enter safe state if the temperature drops below -40°C. Hard- or soft reset required.

European Directives

Description	Directive	Comment
EC type approval	2014/30/EU	EMC Directive
	2009/64/EC	EMC Directive (Agricultural or forestry)
CE mark	-	Danfoss EU declaration
EC type approval	ECE R10	Approval number 10R-059021
RoHS	2015/863/EU	

Functional Safety

Important - Refer to PVED-CLS safety manual for details and system assumptions for correct application of the below specifications.

Description	Applicable Standard	Comment
Safety Integrity Level	IEC 61508 ed. 1	SIL 2
Hardware Fault Tolerance, HFT	IEC 61508 ed. 1	HFT = 1
Architecture	IEC 61508 ed. 1	1oo2
PFH	IEC 61508 ed. 1	5.77x10 ⁻⁸
		Siemens SN29500 @ 80°C
Component type	IEC 61508 ed. 1	B (complex)
SFF	IEC 61508 ed. 1	98%
Diagnostic Coverage, DC	IEC 61508 ed. 1	97%
Proof test interval/mission time	IEC61508, ISO 13849	20 years
	EN 16590	

Technical Information

PVED-CLS Controller for Electrohydraulic Steering

Product Ratings

Description	Applicable Standard	Comment
Performance Level (PL, AgPL)	ISO 13849	PL d
	EN 16590	AgPL d
Architecture category	ISO 13849 / EN 16590	Category 2 (with EHPS valve)
		Category 3 (with OSPE, EHi-E/EHi-H valve)
MTTFd (per channel)	ISO 13849 / EN 16590	36 years (off road)
		57 years (active on road)
Diagnostic coverage	ISO 13849 / EN 16590	Main channel 97%
		Safety channel 95%
Common Cause Analysis score	ISO 13849 / EN 16590	>65 points
Software Requirement Level, SRL	EN 16590	3

EN 16590 is ISO25119 modified.

Material handling and shipping

Description	Applicable Standard	Comment
Free fall from 122cm with packaging; PVED-CLS spare part	500B0430en	Danfoss standard
OSPE, EHPS, EHi-E/EHi-H	500B0430en	Danfoss standard

Temperature

Description	Applicable Standard	Comment
Cold test	IEC 60068-2-1, test Ad	See note
Storage low temperature	IEC 60068-2-1, test Ab	
Dry heat, storage high temperature	IEC 60068-2-2, test Bb	
Dry heat, operating high temperature, max. load	IEC 60068-2-2, test Bd	See note
Change of temperature, cycle	IEC 60068-2-14, test Nb	

Temperature is tested to extended specifications. Contact your Danfoss Power Solutions representative for details.

Mechanical vibration and shock

Description	Applicable Standard	Comment
Mechanical shock (operational)	EN60068-2-29 (BS)	
Mechanical vibration (random)	IEC 60068-2-64, test Fh	See note
Mechanical vibration (sine sweep)	IEC 60068-2-6, test Fc	See note

Mechanical vibration and shock is tested to extended specifications. Contact your Danfoss Power Solutions representative for details.

Enclosure and connector

Rating is only valid with Deutsch mating connector plugged into the PVED-CLS.

Description	Applicable Standard	Comment
Dust ingress	EN 60529 (BS)	IP6X
		IP5X

Product Ratings

Description	Applicable Standard	Comment
Water ingress (hose washing)	EN 60529 (BS)	IPX6
Water ingress (pressure washing)	DIN 40050-9	IPX9K. See note

The Deutsch connector is designed to meet IPX7 and limits the overall ingress capability.

Corrosive Atmosphere

Description	Applicable Standard	Comment
Salt spray	IEC 60068-2-11	Test 2 Ka. See note
Chemical resistance	BS7691	See note

Corrosive atmosphere is tested to extended specifications. Contact your Danfoss Power Solutions representative for details.

Combined Environment

Description	Applicable Standard	Comment
Damp heat, steady state	IEC 60068-2-78	
Humidity Icing Cycle	GS-0027C	Danfoss standard
Combined environment	Danfoss standard	Combined thermal and vibration stress test. See note.

Contact your Danfoss Power Solutions representative for details.

Electrical steady-state

Description	Applicable Standard	Comment
Operating voltage	Danfoss standard	Withstand minimum and maximum voltage for 8 hours
Over-voltage	Danfoss standard	Withstand 36VDC for 5 minutes.
Reverse polarity	Danfoss standard	Withstand -36VDC at power input for 5 minutes.
Short circuit to ground/supply	Danfoss standard	Withstand short-circuiting each pin to ground and battery supply for 5 minutes respectively.
Power up operational requirements	Danfoss standard	Power-up at 9V \pm 5%.
Power-up time, PVED-CLS electronics	-	1.8 seconds

EMC – Immunity tests - Conducted interferences

Description	Applicable Standard	Comment
Accessory Noise Test	ANSI/SAE EP455, section 5.11.1	See note
Batteryless Operation Test	ANSI/SAE EP455, section 5.11.2	See note
Inductive Load Switching Test	ISO 7637-2:2004, (Pulse 1)	See note
Positive Inductance Transient Tests	ISO 7637-2:2004, (Pulse 2a & 2b)	See note
Positive and Negative Coupling Test	ISO 7637-2:2004, (Pulse 3a & 3b)	See note
Cranking Test	ISO 7637-2:2004, (Pulse 4)	See note
Load Dump Test	ISO 7637-2:2004, (Pulse 5a)	See note
Mutual Coupling Tests	ANSI/SAE EP455, section 5.11.6	See note

Contact your Danfoss Power Solutions representative for details.

Product Ratings

EMC – Immunity tests – Radiated interferences

Description	Applicable Standard	Comment
Radiated Immunity Test - ALSE	ISO 14982:1998	See note
	ISO 11452-2:2004	
	ISO 13766	
	EN 13309	
Radiated Immunity Test – Strip-line	ISO 11452-5	See note
Bulk Current Injection Test	ISO 11452-1:2005	See note
	ISO 11452-4:2005	
Direct Radio Frequency (RF) Power Injection	ISO 11452-7:2003	See note

[Contact your Danfoss Power Solutions representative for details..](#)

EMC – Emission tests

Description	Applicable Standard	Comment
Radiated Emissions Test	ISO 14982	See note
	2009/64/EC	
	CISPR 25:2008	
Conducted Emission Test	CISPR 25:2008	See note

[Contact your Danfoss Power Solutions representative for details.](#)

EMC – Electrostatic discharge immunity tests

Description	Applicable Standard	Comment
Electrostatic Discharge – Non-operational	ISO 10605:2008	See note
Electrostatic Discharge – Operational	ISO 10605:2008	See note

[Contact your Danfoss Power Solutions representative for details.](#)

Reliability/Durability

Description	Min.	Max.	Unit	Comment
Useful life-time		10000	Hours	Accumulated operating hours

Product Installation and Startup

Mating Connector

The PVED-CLS valve controller housing is designed for use with 12 pin Deutsch® connector.

Description	12 pin Deutsch connector
PVED-CLS housing mating connector	DT04-12PA-B016 plug assembly

Product Installation

Grounding

Topic	Description
Grounding	Proper operation of any electronic control system requires that all control modules including displays, microcontrollers and expansion modules be connected to a common ground. A dedicated ground wire of appropriate size connected to the machine battery is recommended.
Sensor grounding	Analog sensors shall use the dedicated PVED-CLS sensor ground pin for grounding to avoid unintended ground offsets. This is valid regardless of the sensor is supply voltage source.
Hot plugging	Machine power should be off when connecting to mating connector.
PLUS+1 USB/CAN Gateway	Communication (software uploads and downloads and service and diagnostic tool interaction) between PLUS+1 modules and a personal computer (PC) is accomplished using the vehicle's CAN network. The PLUS+1 CG150 USB/CAN gateway provides the communication interface between a PC USB port and the vehicle CAN bus. When connected to a PC, the gateway acts as a USB slave. In this configuration, all required electrical power is supplied by the upstream PC host. No other power source is required. Refer to Danfoss Power Solution literature number AQ152886483724, for gateway set-up information. Refer to the CG150 USB/CAN Gateway Data Sheet, literature number AI152886484069, for electrical specifications and connector pin details.
PLUS+1 compliance	PLUS+1 service compliant
Software flashing	KWP2000 or PLUS+1 KWP2000
Parameterization	KWP2000 or PLUS+1 KWP2000

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