MAKING MODERN LIVING POSSIBLE

Technical Information

Electrohydraulic Actuators
PVED-CC, Series 4



Revision history

Table of revisions

Date	Changed	Rev
October 2015	New cover image	0307
March 2015	Gray coding added under code numbers	DG
February 2014	Service Tool chapter, images change	DF
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February 2006 - Apr 2013	Various updates	BA - DD
January 2005	New Edition	AA

Contents

Reference

Acronyms used for PVG and PVE 7
Literature reference for PVG/PVE products 8
Standards used for PVED-CC 8

General information

PVED-CC introduction 9
PVE stands for PVE actuator 9
Overview for PVED-CC 10
PVG functionality 12

PVED-CC functionality

Mechanical sub-system 14
- Housing 14
- Cable kit 14
- PVED-CC mounting 15
- Linear Variable Differential Transducer (LVDT) 16
- Spool neutral spring 16

Hydraulic sub-system 16
Electrical and electronic sub-system 16
Communication 17
Computerized sub-system 18
- Power On Self Test (POST) 18
- Full operational mode 18
- Hand operational mode 19
- Emergency mode 19
- Fault mode 19

Settings and system data 19
- Process data 19
- OEM data 19
- Spool data 19
- General part details 19

Logging 20

Safety description

Definition 21
Concept 21
POST–Power On Self Test 21
Runtime fault monitoring 21
- Fault origin category 21
- Fault severity level 22

Fault Reaction 22
- Recorded and reported solenoid disabling 22
- Recorded and reported ignorance 22
- Unrecorded reaction 22

Fault recovery 22
- Reboot 22
- Resume 22

Data section

Declaration of Conformity 23
Operational conditions 23
Performance 23
Dimensions and layout 24
Hydraulic data 25
- Pilot oil system 25

Communication 27
- LED 27
- CAN 27

Parameter description 27
- Commercial identifiers 28

Contents

Communication identifiers ... 28
Firmware identifiers ... 28
Service parameters ... 28
Valve interface settings ... 28
Communication parameters ... 28
Safety parameters ... 28
Behavior parameters ... 29
Name field J1939 ... 29
Function instance ... 29
Component Id ... 30
Part number ... 30
Serial number ... 30
Software naming ... 30
Software details ... 30
Scaling ... 30
Slope curve ... 31
Ramp ... 31
Invert ports ... 31
Float threshold ... 32
AVEF send out time ... 32
AVC time out (AVCTO) ... 32
Power save enable ... 32
Fault recovery – Fault monitoring mode ... 32
Fault monitoring General Time Out (GTO) ... 33
Fault monitoring Float Time Out (FTO) ... 33
KWP2000 Enable ... 33
KWP2000 Id ... 33
KWP2000 max time ... 33
Spool curve ... 33
Float spools ... 34

Warnings

PVED-CC warnings ... 35

ISO 11783 CAN interface

Parameter setting ... 36
Software ID ... 37
Component ID ... 37
Requesting PGN' s ... 38
Fault mode ... 39

State machine and operational modes

Power On Self Test ... 41
uCSM ... 41
AVEF ... 42
AVEF interpretation ... 42
Interpretation with software version 2.4 and older ... 44
Full operational mode ... 45
Closed loop ... 45
Spool positioning ... 45
Flow control ... 45
Hand operational mode ... 46
Emergency stop ... 47

Error description

Error code walk through ... 48
Non-expected event ... 48
Recovery ... 48
Settings ... 48
General timeout (GTO) ... 48
Float timeout (FTO) ... 48

Contents

Auxiliary valve timeout (AVCTO) ... 48
Power save (OEM) ... 48
Spool curve ... 48
Float available (spool) ... 49
Error codes ... 49
1's complement redundancy test ... 49
1st boot ... 49
Reserved ... 49
Division by zero ... 49
CapCom values ... 49
Variable truncation ... 50
Verified write to cell error ... 50
Reserved ... 50
Interpolation check ... 50
Estimate calibration values error ... 50
PWM calibration values error ... 50
Mechanical Spool Compensation values ... 51
Reserved ... 51
Spool data and Float available ... 51
Reserved ... 51
Reserved ... 51
CRC16 check / Parameter memory ... 51
Fall back to old values ... 52
CRC16 check / Program memory ... 52
Main spool cannot reach neutral from retract ... 52
LVDT wiring error ... 52
Power supply above specified range ... 52
Power supply below specified range ... 52
No answer on handshakes ... 53
Power-on self test failed ... 53
Time value for CL control out of range ... 53
Main spool cannot reach neutral ... 53
Main spool cannot reach float position ... 53
Main spool not in neutral at boot up ... 54
Main spool position is greater than the reference ... 54
Main spool position and reference are in opposite directions ... 54
Float threshold has not been passed ... 54
Time guarding on Auxiliary Valve Command ... 54
Illegal CAN address ... 55
Command out of range ... 55
Scaling error ... 55
Ramps error ... 55
Float threshold error ... 55
Dead band compensation error ... 55
Slope error ... 56
Shape error ... 56
Invert port error ... 56
Illegal combination of Port Flow Command and Blocked state ... 56
Illegal combination of Port Flow Command and Float state ... 56
Port flow command above 100% ... 56
Illegal valve state ... 57
Illegal valve state and illegal port flow command ... 57
Illegal combination of inverted ports and float properties ... 57
Errors overview table ... 57

Service tool

Requirements ... 59
PLUS+1® PVE Service Tool S4 DJ ... 59
Installation ... 59
Use of service tool ... 60

Contents

Choosing PVED-CC (ECU) 61
Process data screen 62
Live view screen 63
Error Log screen 64
Spool Data screen 65
OEM Data screen 66
Calibration screen 66
Use case 67
Creation of master file 67
PVED resetting to new parameter files 67

Ordering

Parameter agreement template 68
Factory settings for spare part PVED-CC 68
PVED-CC setting agreement for PVG 69

Code numbers

PVED-CC code numbers 70

Reference

Acronyms used for PVG and PVE

Acronyms	Description
ASIC	Application Specific Integrated Circuit - the part of the PVE where spool position is controled to follow setpoint
ATEX	Certificated for use in explosive environment
AVC	Auxillery Valve Comand - ISOBUS/J1939 standard signal for valve control
AVCTO	Auxillery Valve Comand Time Out - Fault monitoring setting
AVEF	Auxillery Valve Estimated Flow - ISOBUS/J1939 standard signal for valve feedback
CAN	Controller Area Network - Communication method used by PVED
CLC	Closed Loop Circuit
CRC	Cyclic Redundancy Check - Method for ensuring validity of data.
-DI	PVE with Direction Indication
DM1	Diagnostic Message 1 - J1939 message informing about present fault
DM2	Diagnostic Message 2 - J1939 message informing about fault history
DM3	Diagnostic Message 3 - J1939 message clearing fault history
DSM	Device State Machine. Deterministic description of system process
ECU	Electronic Control Unit
EH	Electro Hydraulic
-F	PVE for Float spool. Two variants: 4 pin with float at 75%. 6 pin with separate float.
FMEA	Failure Mode Effect Analysis
ISOBUS	Communication standard for CAN
J1939	Communication standard for CAN
LED	Light Emitting Diode
LS	Load Sensing
LVDT	Linear Variable Differential Transducer - Position sensor
NC	Normally Closed solenoid valve in PVE
NC-H	Normally Closed standard solenoid valve in PVEH
NC-S	Normally Closed solenoid valve Super in PVES
NO	Normally Open solenoid valve in PVE
PLC	Programmable Logical Circuit
PLUS+1®	Trademark for Danfoss controllers and programming tool
POST	Power On Self Test. Boot up evaluation for PVED
Pp	Pilot Pressure. The oil gallery for PVE actuation
PVB	Proportional Valve Basic module - valve slice
PVBS	Proportional Valve Basic module Spool
PVBZ	Proportional Valve Basic module Zero leakage
PVE	Proportional Valve Electric actuator
PVEA	PVE variant with 2-6 % hysteresis
PVED	PVE variant Digital controlled via CAN communication
PVEH	PVE variant with 4-9% Hysteresis
PVEM	PVE variant with 25-35% hysteresis
PVEO	PVE variant with ON/OFF actuation
PVEP	PVE variant PWM controled
PVES	PVE variant with 0-2% hysteresis
PVEU	PVE variant with US 0-10V
PVG	Proportional multi-section Valve Group

Reference

Acronyms	Description
PVHC	PV variant with High Current controlled valve actuator
PVM	Proportional Valve Manual control with handle
PVP	Proportional Valve Pump side module.Inlet
PVS	Proportional Valve end plate
PVSK	Proportional Valve end plate crane. Inlet module with Spool Control
PWM	Pulse Width Modulation
S4 DJ	Series 4 Digital J1939 service tool software for PVED-CC
SAE	Society Automotive Engineering
-R	PVE with Ramp function
-NP	PVE with solenoid disable in Neutral Position
-SP	PVE with Spool Position feedback
uC	Microcontroller
uCSM	Microcontroller State Machine
U_{DC}	Power supply Direct Current; also called V_{bat} for battery voltage
U_S	Steering voltage for the PVE control; also called V_S

Literature reference for PVG/PVE products

Literature reference

Literature title	Type	Order number
PVG 32 Proportional valve group	Technical Information	520L0344
PVG 100 Proportional valve group	Technical Information	520L0720
PVG 120 Proportional valve group	Technical Information	520L0356
PVG 32 Metric ports	Technical Information	11051935
PVED-CC Electro-hydraulic actuator	Technical Information	520L0665
PVED-CX Electro-hydraulic actuator	Technical Information	11070179
Basic module for PVBZ	Technical Information	520L0721
PVSK module with integrated diverter valve and P-disconnect function	Technical Information	520L0556
PVPV / PVPM pump side module	Technical Information	520L0222
Combination module PVGI	Technical Information	520L0405
PVSP/M Priority module	Technical Information	520L0291

Standards used for PVED-CC

- International Organization for Standardization:
  - ISO 11898-2 Road vehicles, CAN, Part 2, High-speed medium access unit (physical layer)
  - ISO 13766:2006(E) Earth moving machinery, Electromagnetic compatibility
  - ISO 13849 Safety of Machinery
- EN 982: 1996 + A1:2008, Safety of machinery – Safety requirements for fluid power systems and their components, Hydraulics
- SAE J 1939
- ISOBUS: ISO 11783 CAN Interface
- EU Directive: EMC directive 2004/108/EC

General information

PVED-CC introduction

The Danfoss PVED-CC is a digital (D) controlled PVE-Series 4 actuator for PVG 32 and PVG 100. The PVED-CC follows the modular Danfoss concept.

CC is an abbreviation for CAN bus Communication. The communication is compliant to the SAE J1939 protocol and the ISOBUS standard for flow control.

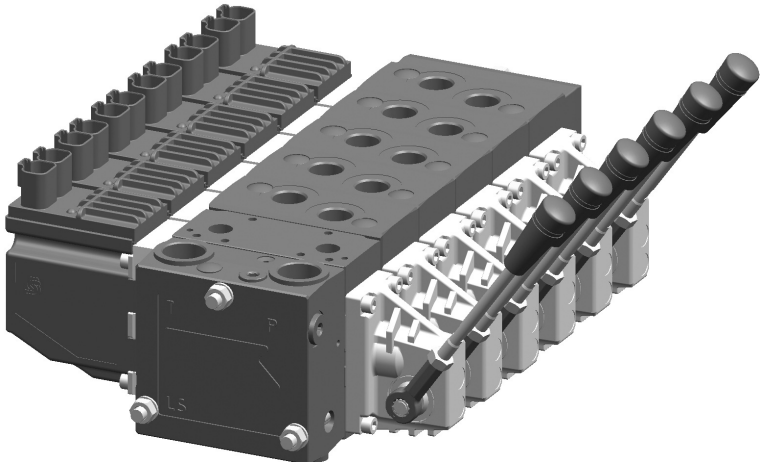
The PVED-CC has proven its worth and is used in various types of automotive hydraulic applications with high demands to precision and controllability.

The PVED-CC can be controlled by a Danfoss PLUS+1® GUIDE application or other devices capable of using communication as defined in this Technical Information.

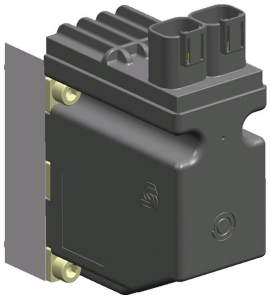
Customizing of the PVED-CC is done by parameter setting. Settings can be made by the PLUS+1® Service Tool, the WebGPI service tool or by a CAN gateway that have the same abilities.

PVG with PVED-CC can be delivered with customer defined settings out of factory.

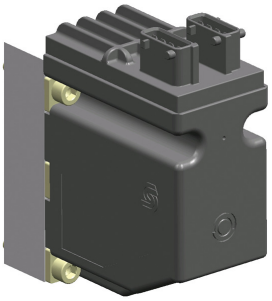
PVG with PVED-CC



PVED-CC with DEUTSCH connector



PVED-CC with AMP connector



PVE stands for PVE actuator

The Danfoss PVE is built on more than thirty years experience of electrical valve control and is the perfect fit for our high performance proportional valves PVG 32, PVG 100 and PVG 120, as it is for our EH steering.

All our products are developed in close cooperation with system manufacturers from the mobile hydraulic market. That is the reason for our high performance in all market segments

General information

The PVE can be controlled from a switch, a joystick, a PLC, a computer or a Danfoss PLUS+1® microcontroller. The PVE is available in multiple variants. A short list here just gives the main variations.

Available PVE variants

Actuation	On/Off
	Proportional - Closed loop controlled
	Proportional - Direct control
Control signal	Voltage
	PWM
	Current (PVHC)
Precision	Standard precision
	High precision
	Super high precision
Feedback	Spool position
	Direction indicator
	Error
	None
Connectors	DEUTSCH
	AMP
	DIN/Hirschmann
Fault detection and reaction	Active
	Passive
	None
Power supply	11 V – 32 V multi-voltage
	12 V
	24 V

Overview for PVED-CC

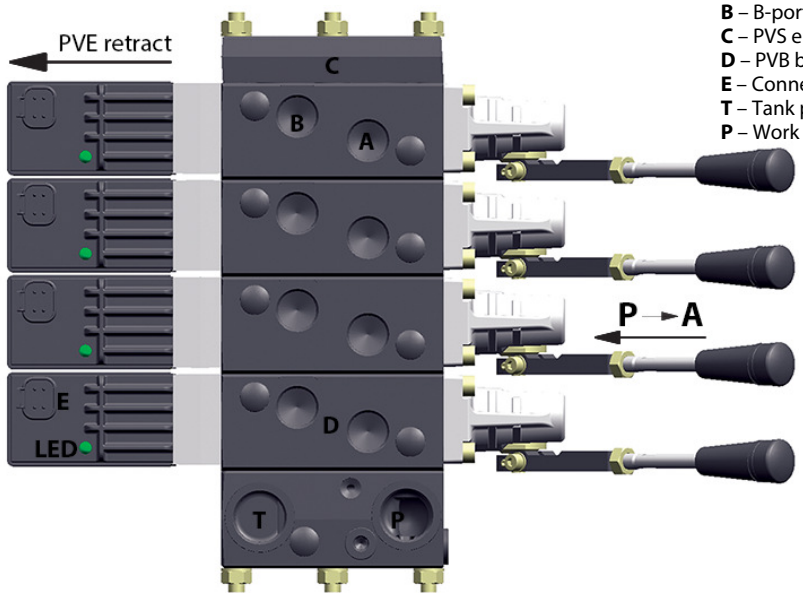
With the PVED-CC a hydraulic application with PVG can have up to sixteen individually controlled valves on one CAN bus. Giving full control and feedback for every work function. This requires multiple PVG.

The oil flow out of the work function (A- or B-port) can be controlled by a combination of the following:

- PVED-CC controlling the spool position using pilot oil pressure.
- A handle (PVM) in mechanical interface with the spool.
- The oil flow into the PVG can be controlled using an electrically controlled main oil valve (PVSK). The PVSK can also supply an additional PVG via the High Pressure Carry Over (HPCO) port. PVG oil supply can be controlled by a PVED-CC (PVEO-DI) on a PVSK.

General information

PVG 32 structural lay-out with naming



Legend:
A – A-port
B – B-port
C – PVS end plate
D – PVB basic module
E – Connector Pin
T – Tank port
P – Work flow

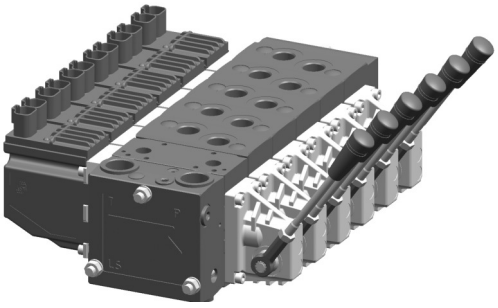
The PVED-CC uses the ISOBUS and J1939 protocol, thus following the standard protocols. The physical layer for CAN communication applies to ISO 11898-2 high speed CAN.

The spool is controlled by flow commands in steps of 0.4% or by spool position with 250 positions in each direction and dead band compensation. Monitored manual operation is possible.

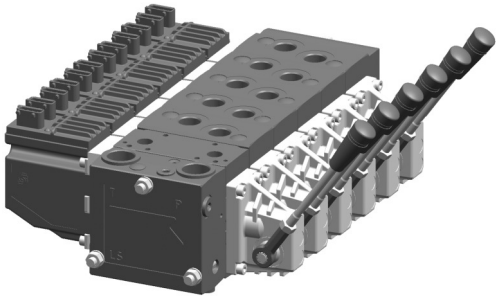
The embedded system also monitors safety. Spool position, communication, electronics, memory, calculations and temperature are continuously evaluated and all violations are broadcasted and logged.

To avoid unnecessary power consumption, the PVED-CC has the *Power Save* feature, where power consumption is reduced by almost 90% when the spool is in neutral.

Standard mounted PVG, PVED-CC with DEUTSCH connector

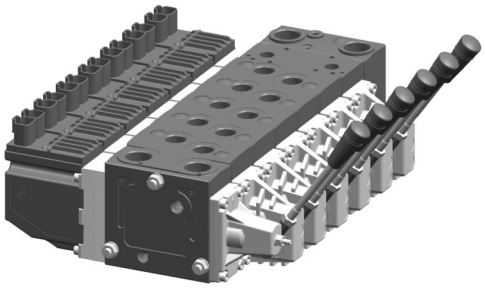


Standard mounted PVG, PVED-CC with AMP connector

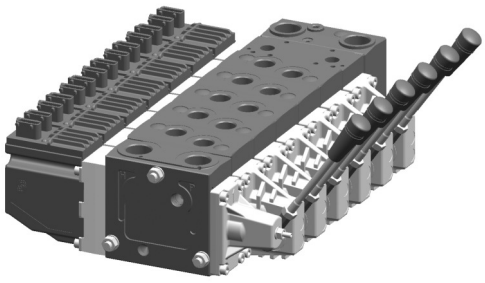


General information

Option mounted PVG with PVSK, PVED-CC with DEUTSCHconnector



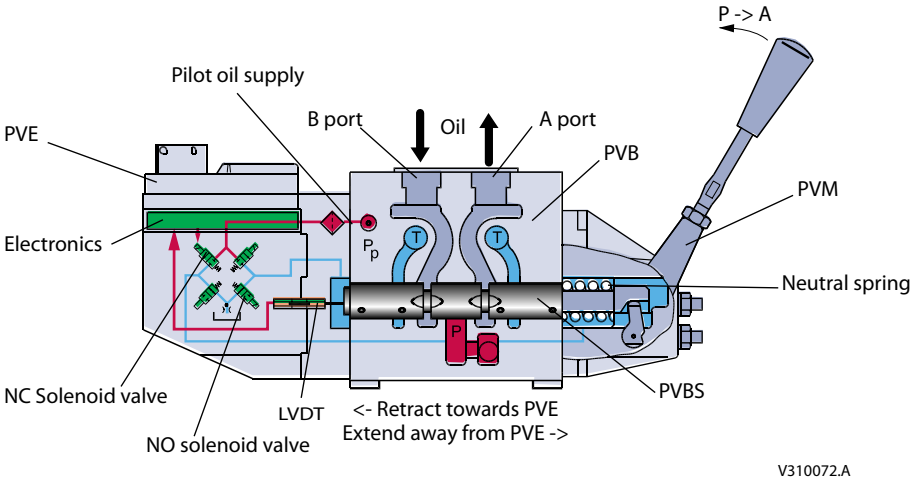
Option mounted PVG with PVSK, PVED-CC with AMP connector



PVG functionality

This chapter will give an overview of the PVG and its functionality.

Valve section with naming - standard mounted - seen from PVP



The PVG valve distributes oil from pump flow to a particular work function in the application via a specific valve section. This is done by moving the spool (PVBS).

Depending on the choice of components the oil work flow enters the PVG through the PVP (proportional valve pump side module) or the PVSK (proportional valve end plate for crane) and enters the PVB (proportional valve basic module) via the P gallery and leaves through the T gallery.

In the figure above you see a valve section seen from PVP towards PVSK with the PVM and PVE standard mounted. PVM and PVE can in general be interchanged, that is called option mounted.

With the spool in neutral, where it is kept by the neutral spring, the connection to the application via ports is blocked.

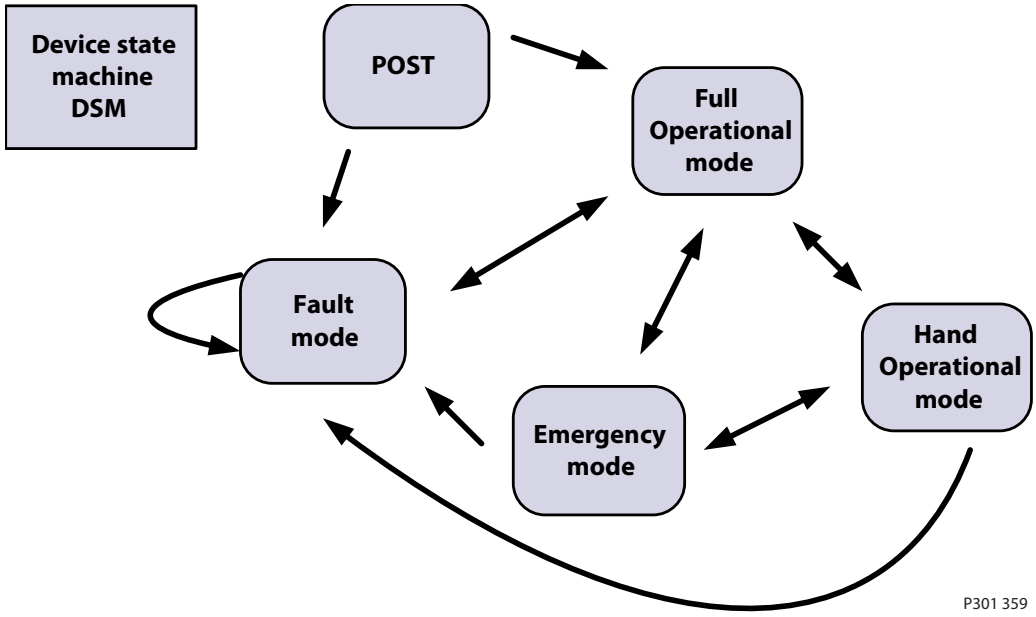
Moving the spool towards the PVE, as in figure 4, opens a connection between P and A and also between B and T. This is done by either pushing the PVM or sending a retract command to PVED. The PVED move the spool by letting Pilot Oil Pressure (Pp) push on the right end of the PVBS and releasing pressure from the left end. For details on PVG please see relevant technical information.

Any PVG with PVM can be operated by PVM alone, independent of a power supply. Any PVG with PVED-CC can monitor PVBS if power and communication conditions are present.

PVED-CC functionality

This section main focus is to provide a brief overview before heading into the following technical chapters. Understanding this section is regarded as a minimum in order to understand the use of the actuator.

Before any installation and use of the PVED-CC it is highly recommended that the user understands the technical chapters as well.



The PVED-CC features four different modes of operation: Full Operational mode, Hand Operational mode, Emergency mode and Fault mode. (Older versions only features Full Operational mode and Fault mode.)

Prior to operation the PVED-CC performs a Power On Self Test (POST) in order to validate the state of electronics, settings and software.

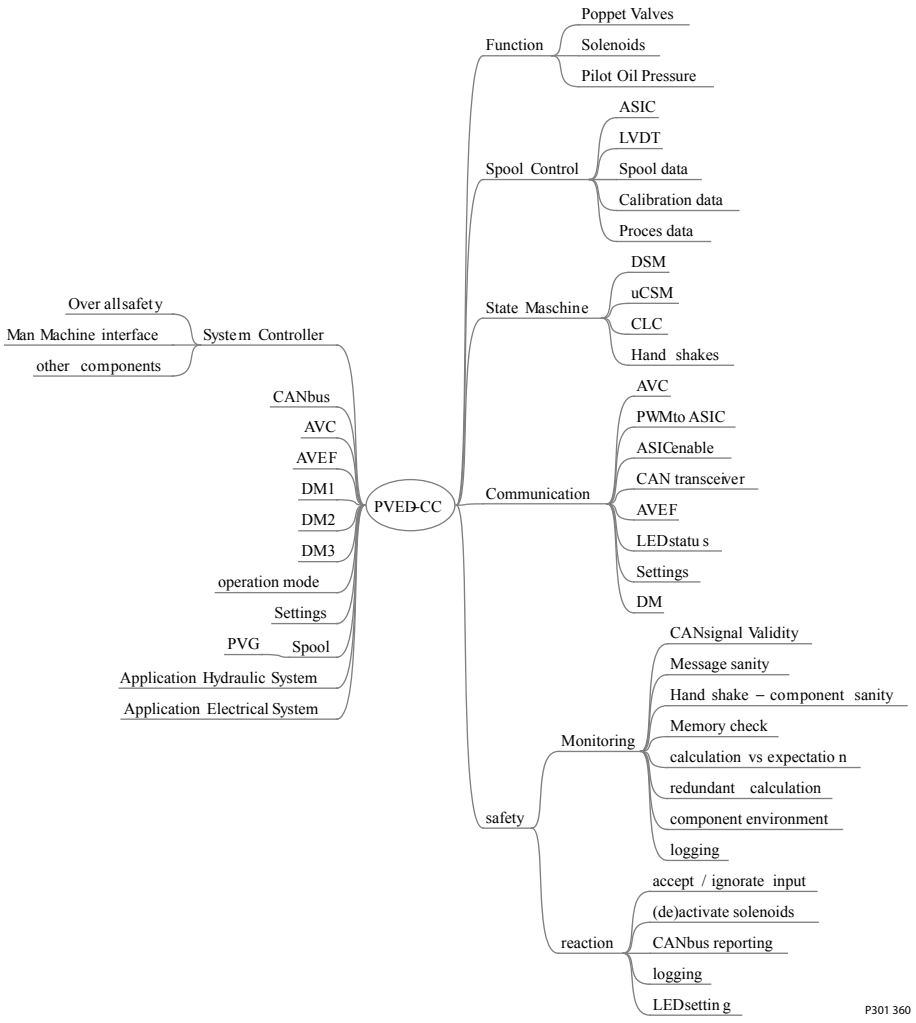
If the PVED-CC recognizes violations of standard operation it will immediately give a detailed feedback on this event. If the violation is regarded as possibly dangerous the PVED-CC will enter fault mode.

The PVED-CC is a mechatronic device, meaning mechanics, hydraulics, electronics and microcontroler interacting with external systems.

The illustration below gives an overview of the actuator tasks. On the left side is external system interaction on the right side internal tasks.

PVED-CC functionality

PVED-CC mechatronical interaction



Mechanical sub-system

Housing

The housing of the PVED-CC protects the internal parts from the environment and gives the optimal interface to cabling, Pilot oil and spool.

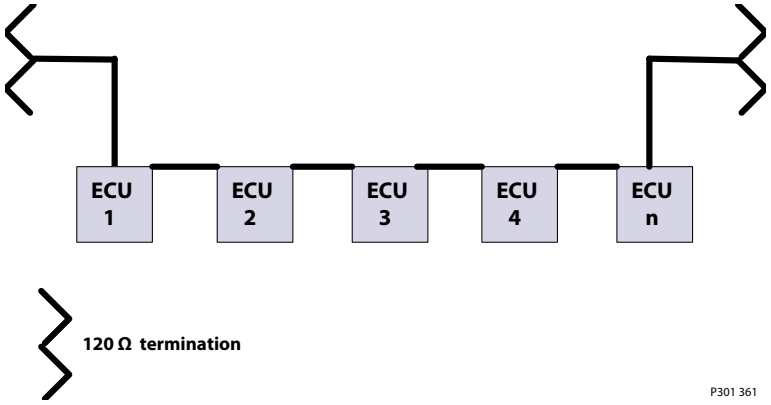
Cable kit

The cabling is one of the great advantages for CAN systems. It reduces the number of cables and gives a simpler system overview.

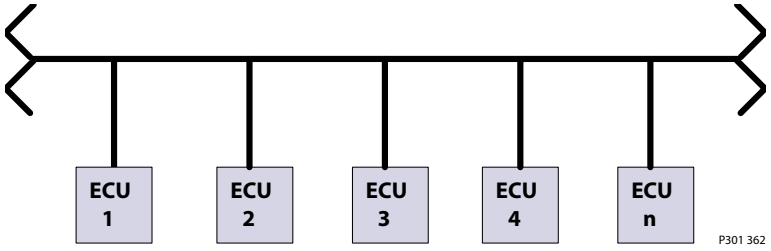
All units (ECU e.g. PVED) are connected by the CAN bus, a CAN high and a CAN low wire which are terminated at the ends. Power and ground wires can with respect to maximum current consumption follow the bus wires.

The bus can either be made as a daisy chain, where the stub from bus to ECU is inside the PVED

PVED-CC functionality



or with stubs going from the back bone to the ECU.

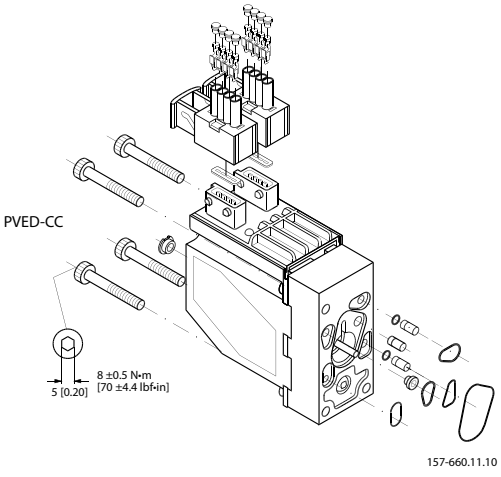


Both solutions have advantages and disadvantages. Danfoss supports the daisy chain solution with cables but the PVED-CC could easily be used with the back bone solution.

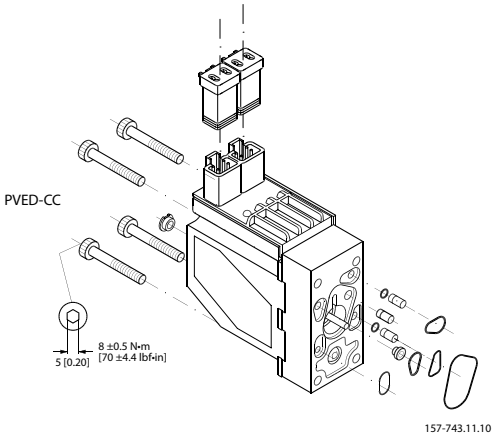
PVED-CC mounting

The Danfoss PVG concept is based on parts interchangeability. This is also valid for the PVED-CC and makes field retrofitting possible. PVED can be mounted on both ends of PVB.

PVED-CC with AMP connector exploded view



PVED-CC with DEUTSCH connector exploded view



Warning

Deviation from recommended torque can harm performance and module.

PVED-CC functionality

Linear Variable Differential Transducer (LVDT)

The Linear Variable Differential Transducer (LVDT) or position sensor is the interface between the mechanical system (spool) and the electronic system.

Warning

The LVDT must never be mechanically adjusted, bent, damaged or partially blocked as this will lead to incorrect information on spool position.

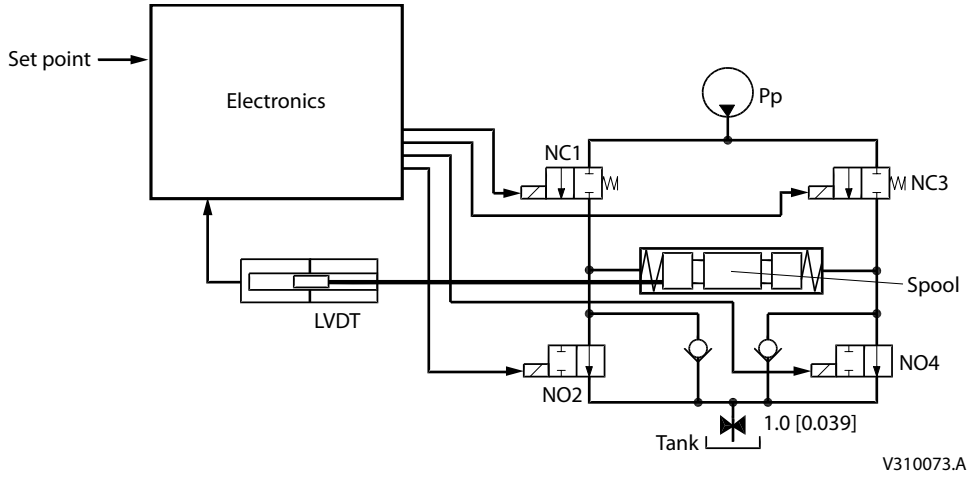
Spool neutral spring

The PVBS neutral spring is an important safety component as it keeps or moves the PVBS in blocked position when solenoid valves are disabled. The spring will keep the A and B port closed as long as the differential pressure is below 6 bar.

Hydraulic sub-system

The hydraulic sub-system is used for moving the spool and thereby opening the valve for work flow.

Pilot oil diagram



The heart of the hydraulic sub-system is the solenoid valve bridge. It consists of four poppet valves, the two upper ones are normally closed (NC-S) with a small bleed, the two lower ones are normally open (NO).

The Pp will work against the PVBS neutral spring when the spool is moved out of blocked (neutral) and together with the spring when going in blocked. This combined with a larger opening in the NO than in the NC-S will give a faster movement towards blocked than out of blocked.

Warning

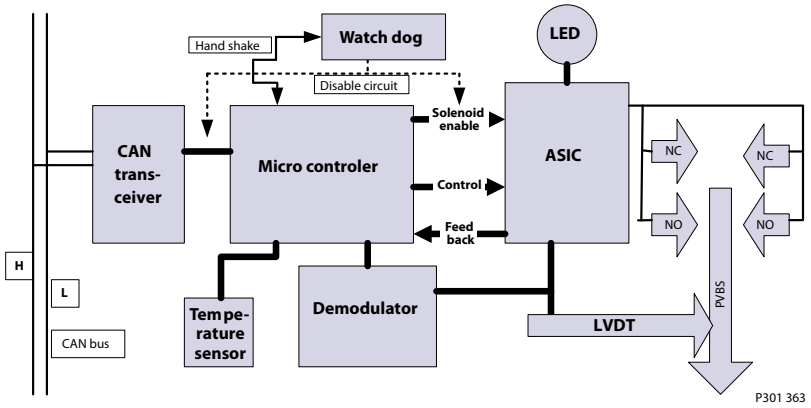
Obstacles for the Pp can have direct influence on spool control. Reduced pilot pressure will limit spool control. Too high Pp can harm the system.

Electrical and electronic sub-system

The PVED-CC is an integrated part of the PVE series 4 technology. The Closed Loop Control of the spool is performed by an ASIC like in all standard PVE but with local intelligence.

PVED-CC functionality

Function blocks for electronics



CAN transceiver	Interface to the bidirectional communication on the bus. The transceiver ensures signal prioritizing, fault free communication and over all signal timing.
Watch dog	If handshakes are not exchanged the solenoids are disabled. If the watch dog detects the problem CAN communication is also disabled.
Demodulator	Verifies the quality of the LVDT signals
ASIC	Application Specific Integrated Circuit. The part of the PVE where the Closed Loop Control (CLC) of spool position defined by the uControler recalculated setpoints is managed.
Microcontroller	Interprets the signals from the system controller. Based on local settings calculates the set point for the ASIC. Evaluates ASIC feedback. Creates feedback messages to the system.
Temperature sensor	The sensor monitors device temperature.
LED	The diode gives optical feedback on actuator state.

Communication

The PVED-CX has three methods of communication.

- Optical from module
- Analogue one way communication
- Digital two way communication

Optical – LED

Blinking and steady light is implemented to facilitate maintenance and application engineering.

Analogue

Analogue communication is implemented.

An analogue signal is sent from active module to monitoring module to enforce redundancy.

Module under surveillance is referred to as neighbor module in settings.

The operational mode of the module under surveillance (neighbor) decides the behavior of the monitoring module.

Digital – CANopen

The CANopen communication is the main method. It is used for:

- Control of module by master. Master defines state transition and set points.
- Reporting from module to master. Module reports spool position and safety violation
- Setting in module by master. Some parameters can be changed.
- Inquiry from master to module.

PVED-CC functionality

CANopen is a communication protocol defined by the society CAN in Automation (CiA). For details in the protocol we refer to CiA.

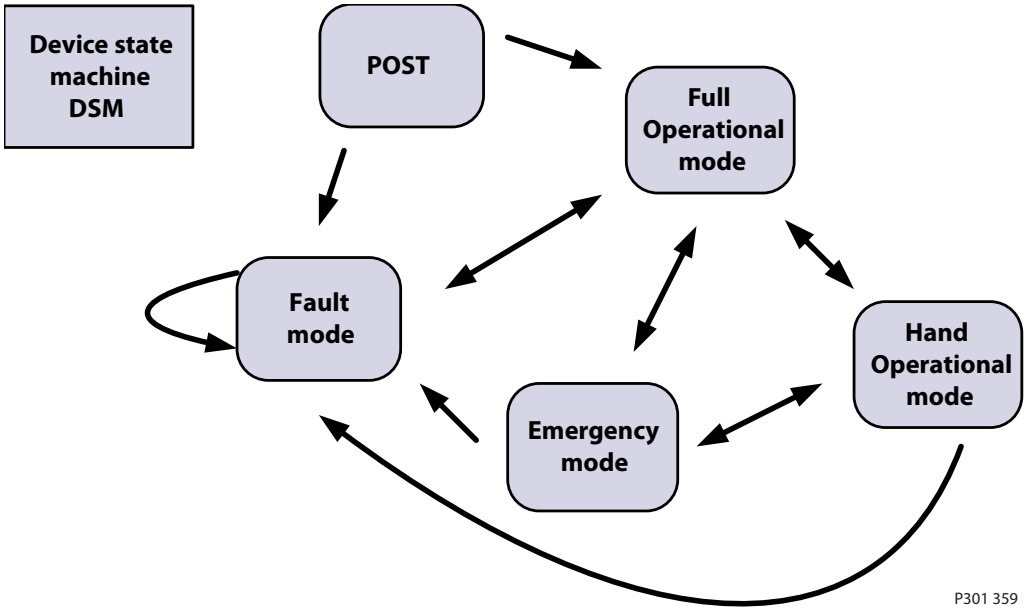
Computerized sub-system

The PVED-CC operation is based on state machines. The top level is according to this figure. Details are available in the data section of this Technical Information.

Warning

Depending on PVED-CC variant, age and software there are variations in communication and control. Read this technical information before implementing new PVED-CC in applications.

DSM for PVED-CC



- Transition out of POST (Power On Self Test) is controlled by PVED-CC
- Transition in and out of fault mode is controlled by PVED-CC
- Transition between Full Operational Mode, Hand Operational Mode and Emergency Mode is controlled by operator. These transitions are not available in older versions.

Power On Self Test (POST)

When power is applied to the PVED-CC it will initialize components and validate component states and parameter settings. If test is passed the PVED will enter Full Operational mode otherwise it will enter Fault mode. In both cases it will, if possible, make itself known to the network by an address claim followed by if needed a fault message (DM1) and then Auxiliary Valve Estimated Flow message (AVEF).

Full operational mode

In full operational mode the PVED-CC controls the spool based on Auxiliary Valves Commands (AVC) from system master. This mode is characterized by:

- No fault is present
- Full control by CAN bus of PVED
- Fault monitoring is active
- Auxiliary Valve Estimated Flow message (AVEF) is transmitted

PVED-CC functionality

Hand operational mode

In hand operational mode the PVED-CC cannot control the spool. This mode is characterized by:

- No fault is present.
- Spool control by PVED is disabled.
- Fault monitoring on spool behavior is disabled. Is maintained on other parameters.
- Auxiliary Valve Estimated Flow message (AVEF) is transmitted

Emergency mode

Emergency mode is similar to Hand operational mode but is entered without any ramping. This mode is characterized by:

- Entered without any delay
- Similar to hand operational mode

Fault mode

In fault mode the PVED-CC monitors and reports if possible.

This mode is characterized by:

- One or more faults are present
- LED is orange or red
- PVED tries to force PVBS to blocked position
- AVC from Master is not followed by the module
- Fault monitoring is active and every second present faults are reported
- Auxiliary Valve Estimated Flow message (AVEF) is transmitted.

Settings and system data

The PVED-CC offers a number of settings for both spool control, fault monitoring and general system settings. A number of system information parameters are available via the service tool. Details are available in the data section of this Technical Information.

Process data

Process data can be considered as user or situation specific values. They are the runtime settings Ramp timing, scaling of set point, variation of progressivity and port inversion and can be changed during operation by an ISOBUS message.

OEM data

OEM data can be considered as application or system specific values. They are a number of safety settings, performance settings and the module communication identifier. Also a set of fall back values for the process data are stored as OEM data.

Spool data

Spool data are parameters used for linearization of the spool. These parameters gives relation between spool position and flow command in order to apply to the ISOBUS standard of 0.4% flow change for each step of the Auxiliary Valve Command (AVC).

General part details

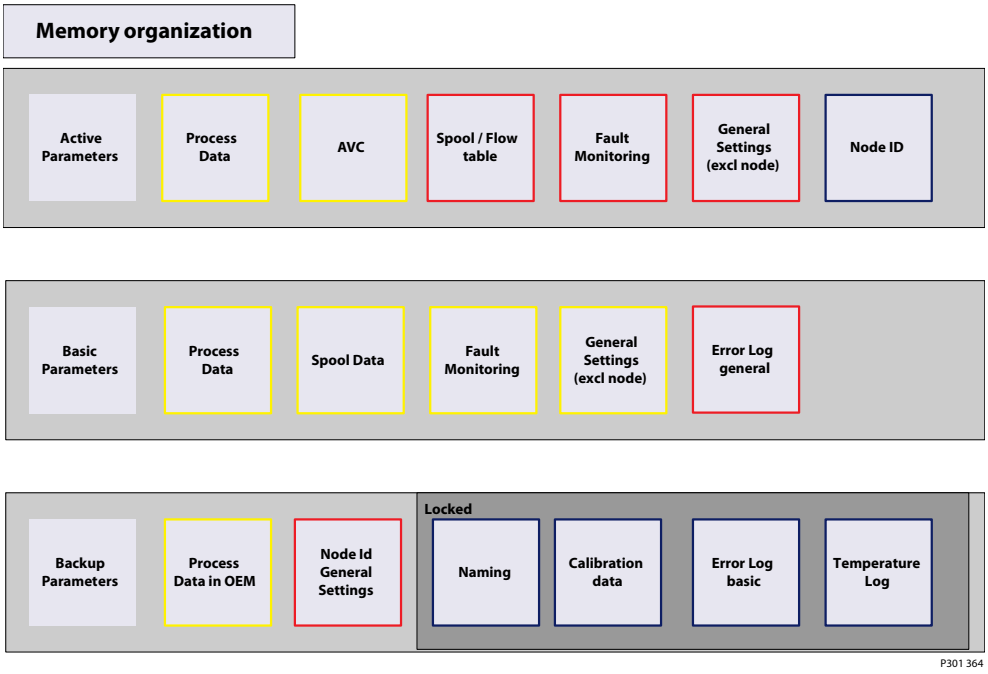
Information like part number, production date, software identification and Name field are also available.

PVED-CC functionality

Logging

An error log with event counter is stored in the EEPROM.

During runtime a temperature histogram for the electronics are stored in the EEPROM.



Safety description

For a general description on Safety in Application please see *PVE Series 4 for PVG 32, PVG 100 and PVG 120 Technical Information*, **520L0553**.

Definition

The Danfoss definition of safe state transition by fault: Depower solenoids and release spool to neutral spring. PVBS to be forced to blocked position (neutral) by neutral spring.

The PVED-CC has Active Fault Reaction, meaning the solenoids are disabled on fault. Less flow than commanded is not regarded as dangerous by the PVED.

Concept

The PVED-CC safety concept is based on two elements:

- POST – Power On Self Test
- Runtime fault monitoring and reaction

The basic elements for product safety are:

- Continuous module self monitoring
- Fault recognition and reaction
- Fault reporting and recording
- Fault recovery

POST–Power On Self Test

When powered the PVED evaluates settings, circuit, sensors and spool interface .

Passing of the POST is a precondition for entering Full Operational Mode.

Runtime fault monitoring

After power on set up and POST the runtime fault monitoring takes over. Every time the uCSM enters the safety task a number of feedbacks are evaluated. In parallel the internal handshake between microcontroller and watch dog is running. The faults are categorized by origin and severity level

Fault origin category

- Internal PVED
  - Handshake fault
  - Calculation faults
  - Memory faults
  - Components faults
  - Temperature fault
- PVED PVG interaction
  - Spool position faults
- System interaction /communication fault
  - Power supply
  - Invalid commands
  - Missing commands
  - CAN bus faults

Safety description

Fault severity level

- Warning. A changes of settings was attempted but could not be followed
- Severe. Based on the present state actuation cannot be continued. This is for fault types permanent and temporary.

Fault Reaction

In case of recognized unintended behavior the PVED-CC can react in three ways.

For some events the reaction is at first occurrence for others after a threshold is passed.

By multiple faults the most severe has priority and the PVED-CC will stay in fault mode until recovered from all faults.

Recorded and reported solenoid disabling

Used by severity level Severe and solenoids are disabled.

If the event is regarded safety or performance threatening the solenoids are disabled (spool forced back to blocked), a distress messages is broadcasted on the CAN bus at occurrence and for as long as present and a record is made in the error log.

Recorded and reported ignorance

Used by severity level Warning and solenoids are not disabled.

A distress messages is broadcasted on the CAN bus at occurrence and as long as present and a record is made in the error log.

Unrecorded reaction

By missing handshake from microcontroller the Watch dog disables the solenoids and the CAN bus interface.

Fault recovery

For events of severity level Severe there are one of two ways of recovery.

Reboot

The event is regarded as system threatening and a system reconfiguration and reevaluation is required.

Resume

the event is regarded as performance/safety threatening but not system threatening. When the fault trigger disappears transmission of two AVC Blocked reactivates the PVED.

For events with severity level Warning no recovery needed. The operator might though need to send a valid setting changes to get a desired performance.

Data section

Declaration of Conformity

The PVED-CC has CE marking according to the EU directive EMC Directive 2004/108/EC. The declarations are available at Danfoss.

Operational conditions

The PVED-CC will only operate according to the table below:

Operational conditions

Mode	Supply			
	Power	CAN control	Pilot oil pressure	Oil main pressure
Electronic test POST	Mandatory	Optional	Optional	Optional
Manual operation	Optional*	Optional*	Optional	Mandatory**
Full operation	Mandatory	Mandatory	Mandatory	Mandatory**

* Mandatory if spool position information is requested.

** If hydraulic performance is expected.

The PVE is designed for use with pilot oil supply. Use without oil supply except intermittent use can harm the system.

The PVE is designed for use with pilot pressure range 10 -> 15 bar [145 -> 220 psi]. Intermittent pressure peaks up to 50 bar [725 psi] can be accepted.

Definition: Extend. Spool is further away from PVED than blocked position. Equals to oil out of B-port by standard mounted PVED.

Definition: Retract. Spool is closer to PVED than blocked position. Equals to oil out of A-port by standard mounted PVED.

Definition: Intermittent is no longer than 5 seconds and not more than once per minute.

Performance

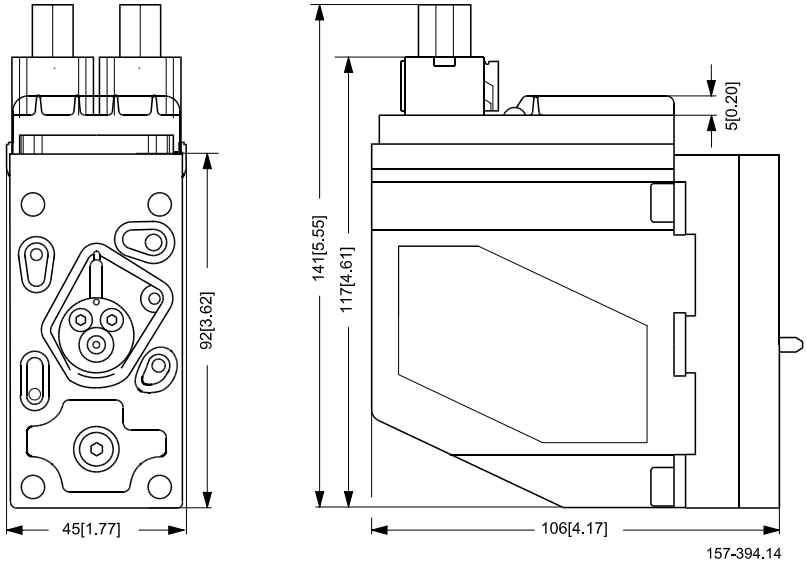
Reaction time for actuation (@ Oil viscosity: 21 ± 0.5 cSt; Pilot pressure (P-T): 13.3 ± 0.5 bar)

Reaction time - function	Solenoids	Minimum	Maximum
From neutral to maximum spool travel	Powered	50 ms	200 ms
From maximum spool travel to neutral	Powered	-	150 ms
From power on to maximum spool travel	Powered	1000 ms	4000 ms
From maximum spool travel to neutral	Disabled	-	175 ms
Power up; from power on to CAN active	-	-	1000 ms
Hysteresis @0.02Hz	-	0 %	1 %

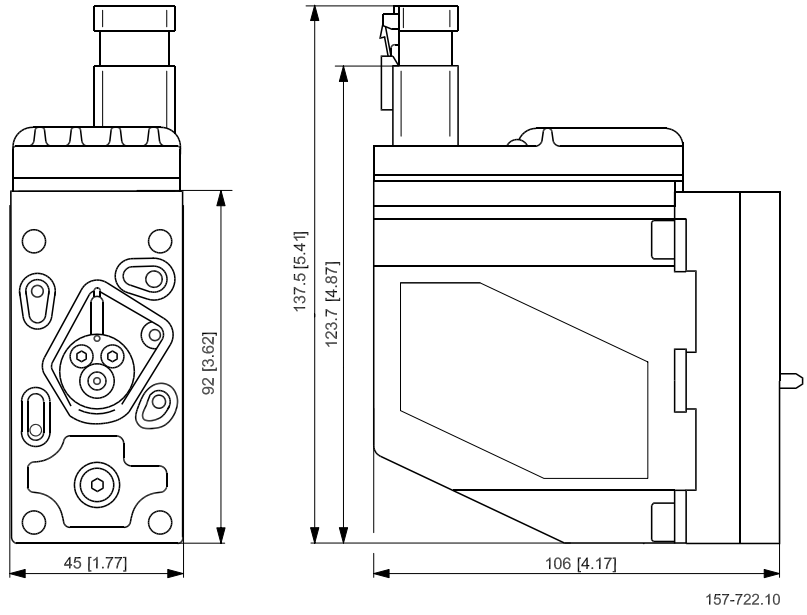
Data section

Dimensions and layout

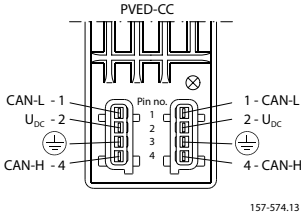
PVED-CC with AMP connector



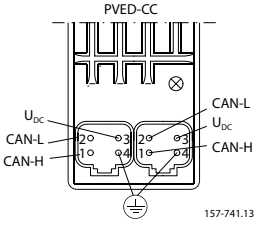
PVED-CC with DEUTSCH connector



AMP version PVED-CC



DEUTSCH version PVED-CC



Data section

Connection PVED-CC

Connector	CAN low	U_{DC}	Ground	CAN high
AMP	pin 1	pin 2	pin 3	pin 4
DEUTSCH	pin 2	pin 3	pin 4	pin 1

Enclosure and connector

Connector	AMP JPT connector	DEUTSCH connector
Grade of enclosure*	IP 66	IP 67

* According to the international standard IEC 529

NB: In particulary exposed applications, protection in the form of screening is recommended.

Voltage and current

Supply Voltage (DC)	
Nominal	11 - 32 V
Minimum	9.5 V (SW alarm 0 V)
Maximum	33.5 V (SW alarm 35.5 V)
Max ripple	5 %
Current Consumption	
Current consumption @ 12 V in Full Operational mode	750 mA
Power consumption in full operational mode	9 W
Current consumption @ 12 V in Hand Operational mode or power save	90 mA
Power consumption in Hand Operational mode or power save	1.1 W

Power consumption is independent on voltage. Activation of solenoid valves by low voltage outside nominal is for short term excep-tions, meaning maximum 10 % of operating time and for max 5 minutes within an hour. Activation of solenoid valves by 9-10 V will give reduced valve performance. Voltage above 36 V and below 8 V will shut down electronics.

Warning

Maximum 10 PVED-CC can be powered on same daisy chain simultainously.

The PVED-CC is in conformity with the EU EMC directive 2004/108/EC and complies to the standard ISO 13766:2006 (E) Earth moving machinery – Electromagnetic compatibility.

16 PVED-CC can be on the same CAN bus simultaneously.

According to J1939, the maximum length for a CAN bus is 50 meter [1970 inch]

Hydraulic data

Pilot oil system

Oil viscosity

Oil viscosity	range	12 → 75 mm^2/s [65 ÷ 347 SUS]
	min.	4 mm^2/s [39 SUS]
	max.	460 mm^2/s [2128 SUS]

Data section

Pilot pressure

Pilot pressure (relative to T pressure)	nom.	13.5 bar [196 psi]
	min.	10.0 bar [145 psi]
	max.	15.0 bar [217 psi]

Oil temperature

Oil temperature	range	30 → 60˚C [86 ÷ 140˚F]
	min.	-30˚C [-22˚F]
	max.	90˚C [194 ˚F]

Operating temperature

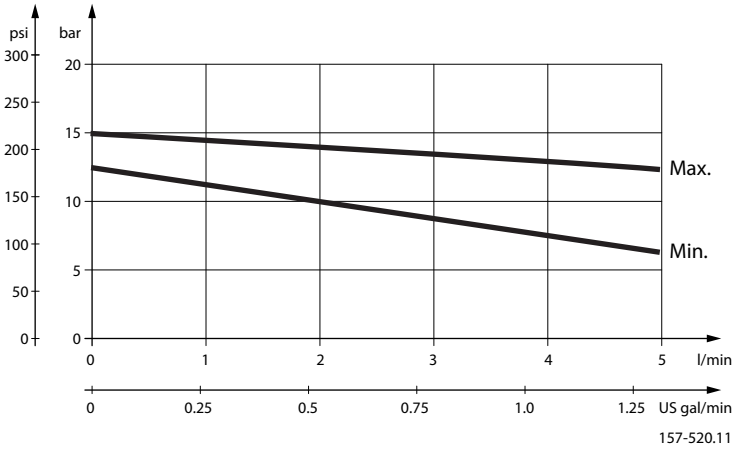
	Min.	**Max.**
Ambient	-30˚C [-22˚F]	60˚C [140˚F]
Stock	-40˚C [-40˚F]	90˚C [194˚F]
Recommended long time storage in packaging	10˚C [50˚F]	30˚C [86˚F]

Filtering in the hydraulic system

Required operating cleanliness level	18/16/13 (ISO 4406, 1999 version)

For further information see Danfoss documentation *Hydraulic Fluids and Lubricants, Technical Information* **520L0463**.

PVP modules, pilot pressure curves



Pilot oil consumption for one PVED-CC

Solenoids depowered	0.2 ÷ 0.4 l/min [0.05 ÷ 0.10 US gal/min]
Spool locked by pilot oil	0.1 ÷ 2 l/min [0.03 ÷ 0.05 US gal/min]
Continuous actuation	0.9 ÷ 1.1 l/min [0.24 ÷ 0.29 US gal/min]
One actuation (neutral to max.)	0.002 l/min [0.0005 US gal/min]

Oil viscosity: 21.0 ± 0.5 cSt, Pilot.

Pilot pressure (P-T): 13.3 ±0.5 bar

Data section

Hysteresis overview

	NC-S	NC-H
Maximum	2.0%	8.6%
Typical	<½%	4.0%

Communication

LED

The PVED-CC has four modes, see the table below:

LED color interpretation

LED color	PVED-CC mode
Green	Full Operation
Yellow	Power save (if the spool is in blocked position for more than 1 s)
	Manual (error)
Red	Fail-silent (ASIC and CAN Transceiver disabled)

CAN

CAN data

Physical layer	ISO11898-2 high speed CAN
Protocol	ISO11783-7 / SAE J1939 (29 bit identifiers)
Baud rate	250 Kbps
Bit timing	TSEG1 = 13 TSEG2 = 4 SJW = 0 BRP = 1

According to this time quanta calculated as per data sheet is tq = 200 n.s. (considering fcpu = 20 MHz).

Therefore:

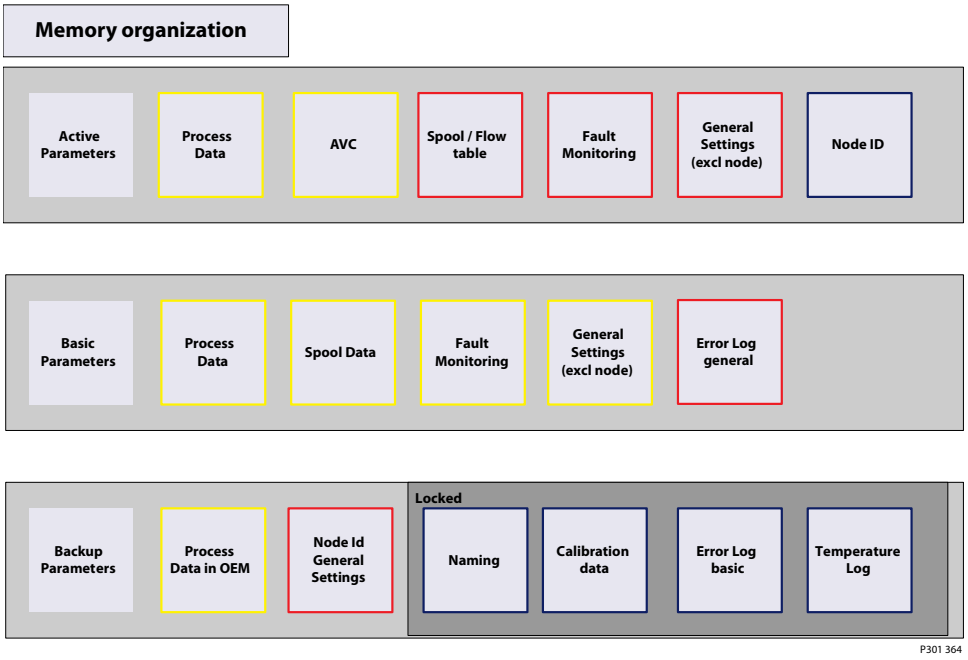
- Before Sample point [t(TSEG1)] = (TSEG1 + 1) x tq = 14 x 200 = 2800 n.s.
- After Sample point [t(TSEG2)] = (TSEG2 + 1) x tq = 5 x 200 = 1000 n.s.
- t(sync-seg) = 1 x tq = 200 n.s.
- 1 Bit time = t(sync-seg) + t(TSEG1) + t(TSEG2) = 200 + 2800 + 1000 = 4000 n.s.
- One sample point at 75 %.
- According to 250 kbps, 1 Bit time = 4000 n.s.

Parameter description

Parameters in the PVED-CC are organized in a hierarchy with active parameters as most important and back up parameters as less important. Yellow framing indicates high accessibility, red low and purple read only. Changing parameters in one position will not necessarily change parameters at other positions. E.g. ramp changed as process data will change performance until next reboot, ramp value changed and stored as process data will have effect until next restore OEM defaults. Changing ramp in OEM data will only have effect for performance if restore OEM data is performed in Process Data screen

Data section

Memory organization



Commercial identifiers

The part number or sales number gives together with the production day the serial number for the PVED-CC. This is a unique identification of every PVE which is also engraved on the cover.

Communication identifiers

The CAN bus identification of the PVED-CC is defined by the name field. The function instance, in this document also called node id or source address, is the only accessible parameter in current versions.

Firmware identifiers

Information about firmware and thus on implemented features is present in the PVED-CC.

Service parameters

Error log and temperature histogram can be read out.

Valve interface settings

Calibration data and spool curve defines software interface to the electrical and mechanical environment.

Communication parameters

Node Id, Estimated Flow Delay, and KWP 2000 parameters defines communication

Safety parameters

For some faults a threshold for recognition can be set. That is done by the General Timeout (GTO), the Float Time Out (FTO) and the auxiliary valve Command Time Out (CTO). The fault recovery conditions can be altered for a number of faults, named monitoring. Also the Power Save setting has influence on system safety and not only power consumption.

Data section

Behavior parameters

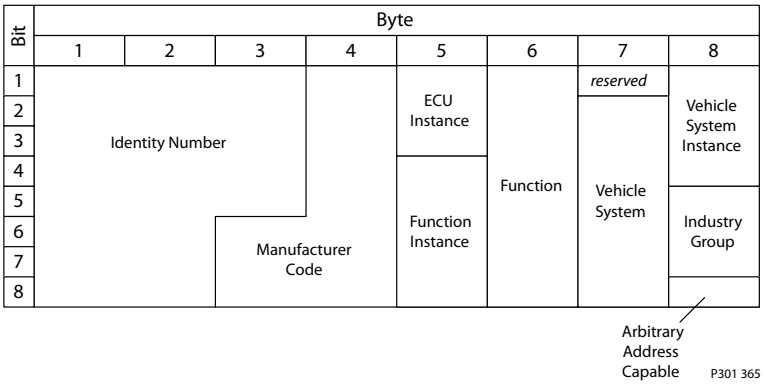
A number of parameters have a direct influence on how the PVED perform on a flow command. These parameters are referred to as process data. These are ramping, scaling, progressivity and port inverting. Also a minimum flow before entering float can be defined. All these parameters can be changed by a single CAN message.

Name field J1939

Dynamic address claiming is not implemented. Parameters are read only. Function instance can only be accessed by service tool protocol.

Back up parameters – Node Id General settings – J1939

Identity Number	201001 (0b 00011000 10001001 01001)	Read Only
Manufacture code	57 (0b 000 00111001) Danfoss	Read Only
ECU instance	0 (0b 000)	
Function instance	0 (0b00000) node id 128 (0x80)	
Function	129 (0b 10000001) auxiliary valve on a tractor	
Reserved	0	
Vehicle system	1 (0b 0000001) tractor for industry group 2	
Vehicle system instance	0 (0b 0000) front vehicle	
Industry group	2 (0b 010)	
msb: byte 8 bit 8 lsb: byte 1 bit 1		



Function instance

Function instance shows the PVED node id.

- 0 (0b00000) node id 128 (0x80)
- 1 (0b00001) node id 129 (0x81)
- 2 (0b00010) node id 130 (0x82)
- …
- 15 (0b01111) node id 143 (0x8F)

Function instance identifies the PVED-CC on the bus as source or target for communication.

In the service tool function instance is shown with decimal number (node Id). Hexa deximal (0x) values are used in communication description. numbers.

Function instance (node Id) 128 (0x80) is default for none configured PVED-CC (spare part).

Back up parameters – Node Id General settings

OEM data. Changes are implemented by boot up

Data section

Range: 128 – 143 (0x80 – 0x8F) Default value 128

Example

	SPN	Signal target	Signal source
18EA8006	18EA	80 (PVED 128)	06 (system CTRL)
1CECFF80	1CEC	FF (Broadcast)	80 (PVED 128)

Component Id

By use of the service tool part number, serial number, software version and software details are available.

Back up parameters – Node Id General settings- read only – J1939.

Part number

Same as sales number. Also engraved on the PVED-CC housing.

Serial number

Example of serial number: 2211A056182

	Factory	Week	Year	Day*	Machine	Id
Engraved	---	22	13	A	05	6182
Soft	N	22	1	A	---	6182

* Day: A-Monday, B-Tuesday, C-Wednesday, D-Thursday, E-Friday, F-Saturday, G-Sunday

Also engraved on the PVED-CC housing.

Software naming

Three digits giving a revision number. E.g. 2.68

Software details

- Software version 268 Revision number
- Project name ISOBUS Protocol format
- Information Release Software status
- Software Part number 11079035
- Hardware Part number 157B4943 Platform identifier. Not sales number
- Hardware Issue 08 Not used parameter
- Software build date 20100121 Compilation information
- Software build time 0953 Compilation information
- Software build host NORLT422 Compilation information
- Software build location Danfoss ApS Compilation information
- Software label ISOBUS_R2.68 Compilation information
- Software CRC 5C58 Compilation information

Scaling

Scaling reduces the set point automatically for the PVED. Scaling is relevant if the control speed must be lowered. The value defines how large a part of the set point is valid. Scaling can be defined independently for both extend and retract.

- Active parameters –Process Data – ISOBUS, is not stored for next session.
- Basic parameters – Process Data – WebGPI, is activated and stored for next session.

Data section

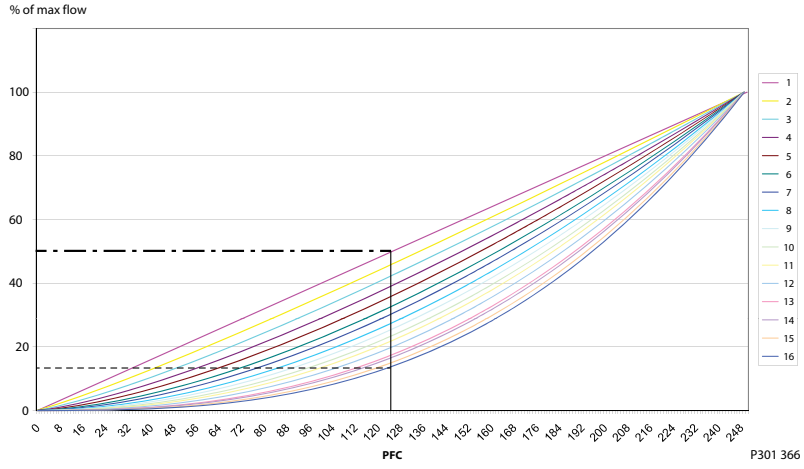
- Back up parameters – Process Data – OEM Data – WebGPI is not activated but stored. Can be moved to Basic Parameters.
- Configurable: Range: 0 % –100 % in steps of 0.4 % (0-250); Default value 100 % (250)

Slope curve

Slope curve is a progressivity scaling of the set point. Slope curve can be used to get finer solution on set point with low flow. Slope curve can be defined independently for both extend and retract.

- with PFC 125 and slope 0 (linear); the flow will be 50% of max flow.
- with PFC 125 and slope 15 (maximum progressivity); the flow will be close to 15 % of max flow.

Spool characteristic curves



- Active parameters – Process Data – ISOBUS, is not stored for next session.
- Basic parameters – Process Data – WebGPI, is activated and stored for next session.
- Back up parameters – Process Data – OEM Data – WebGPI is not activated but stored. Can be moved to Basic Parameters
- Configurable:
  - Range 1 (linear) to 16
  - Default value 1 (linear)

Ramp

Ramp builds in a delay in the flow change. Ramp is relevant if fast change in flow can harm the system. The value defines delay time for transition between 0 % and 100 % of maximum flow. Ramp can be defined independently for both flow growth and lowering in both extend and retract direction.

- Active parameters –Process Data –ISOBUS, is not stored for next session
- Basic parameters – Process Data –WebGPI, is activated and stored for next session
- Back up parameters – Process Data- OEM Data –WebGPI is not activated but stored.

  Can be moved to Basic Parameters
- Configurable: Range: 0s to 4s insteps of16ms(0-250); Default value 0s (0)

Invert ports

Invert port mirrors the flow command in the opposite direction. Invert port can be relevant if joystick is operated from opposite side than standard.

Cannot be used with float spools

- Active parameters – Process Data – ISOBUS, is not stored for next session

Data section

- Basic parameters – Process Data – WebGPI, is activated and stored for next session
- Back up parameters – Process Data- OEM Data – WebGPI is not activated but stored.

  Can be moved to Basic Parameters
- Configurable: Range: none inverted and inverted (0-1); Default value none inverted (0)

Float threshold

Float threshold defines minimum flow before entering float. Float threshold can be used to avoid float state for lifted load. Float threshold cannot support float entering from opposite flow than float side of spool. Ramp builds in a delay in the flow change. Ramp is relevant if fast change in flow can harm the system. The value defines delay time for transition between 0% and 100% of maximum flow. Ramp can be defined independently for both flow growth and lowering in both extend and retract direction..

- Active parameters –Process Data –ISOBUS, is not stored for next session
- Basic parameters – Process Data –WebGPI, is activated and stored for next session
- Back up parameters – Process Data- OEM Data –WebGPI is not activated but stored.

  Can be moved to Basic Parameters
- Configurable: Range: 0% –100% in steps of 0.4% (0-250); Default value 0.4% (1)

Not applying to float threshold will cause a warning.

AVEF send out time

The Auxiliary Valve Estimated Flow (AVEF) is an average in full percentage of the flow over the last 80ms (8 samples). The AVEF can be used for flow sharing, monitoring of unintended movement or reduced flow, handshake from PVED etc.

- Basic parameters – OEM data – WebGPI, is activated by send
- Back up parameters – OEM Data – WebGPI activated and stored for next session
- Configurable: Range: 0 - 64255 ms in steps of 10ms. 65535 (0 x FFFF) is disable; Default value 100 ms.

AVC time out (AVCTO)

The Auxiliary Valve Command (AVC) time out is the maximum time span between two set point commands from the system controller. See also error code description for Time guarding on Auxiliary Valve Command. The AVC Time Out is a handshake monitoring of controller.

- Basic parameters – OEM data – WebGPI, is activated by send
- Back up parameters – OEM Data – WebGPI activated and stored for next session
- Configurable: Range: 0 - 65535 ms in steps of 10 ms. 0 is disable; Default value 0 ms.

Violating AVCTO will cause a fault.

Power save enable

The power save enable reduces the PVED power consumption by 90% when the spool has been in blocked position for more than 1 second.

- Basic parameters – OEM data – WebGPI, is activated by send
- Back up parameters –OEM Data – WebGPI activated and stored for next session
- Configurable: Range: Enabled (0xFF) – Disabled (0); Default value Enabled.

Fault recovery – Fault monitoring mode

The fault recovery defines if a reboot is required for system recovery (Active) after un-demanded spool position or if AVC blocked (passive) can restore the application. Se further description in section Fault monitoring.

- Basic parameters – OEM data – WebGPI, is activated by send

Data section

- Back up parameters –OEM Data – WebGPI activated and stored for next session
- Configurable: Range: Passive (0) – Active(0xFF); Default value Active.

Fault monitoring General Time Out (GTO)

The GTO defines for how long a fault can be accepted before solenoid valves are disabled and DM1 is transmitted. See further description in section Fault monitoring.

- Basic parameters – OEM data –WebGPI, is activated by send
- Back up parameters –OEM Data –WebGPI activated and stored for next session
- Configurable: Range: 250, 500, 750, 1000, 1250, 1500, 1750, 2000 ms; Default value 500 ms.

Fault monitoring Float Time Out (FTO)

The FTO defines for how long a float related fault can be accepted before solenoid valves are disabled and DM1 is transmitted. See further description in section Fault monitoring.

- Basic parameters – OEM data –WebGPI, is activated by send
- Back up parameters –OEM Data –WebGPI activated and stored for next session
- Configurable: Range: 750, 1000, 1250, 1500, 1750 ms; Default value 750 ms.

KWP2000 Enable

The KWP2000 is used for passivating the PVED. This is relevant if busload must be reduced for other purposes.

- Basic parameters – OEM data – WebGPI, is activated by send
- Back up parameters –OEM Data – WebGPI activated and stored for next session
- Configurable: Range: Enable (0xFF) – Disable (0); Default value Enable.

KWP2000 Id

The KWP2000 Id defines whether global addressing or specific addressing must be used for the operation.

- Basic parameters – OEM data – WebGPI, is activated by send
- Back up parameters –OEM Data – WebGPI activated and stored for next session
- Configurable: Range: Specific (0xFF) – Global (0); Default value Global.

KWP2000 max time

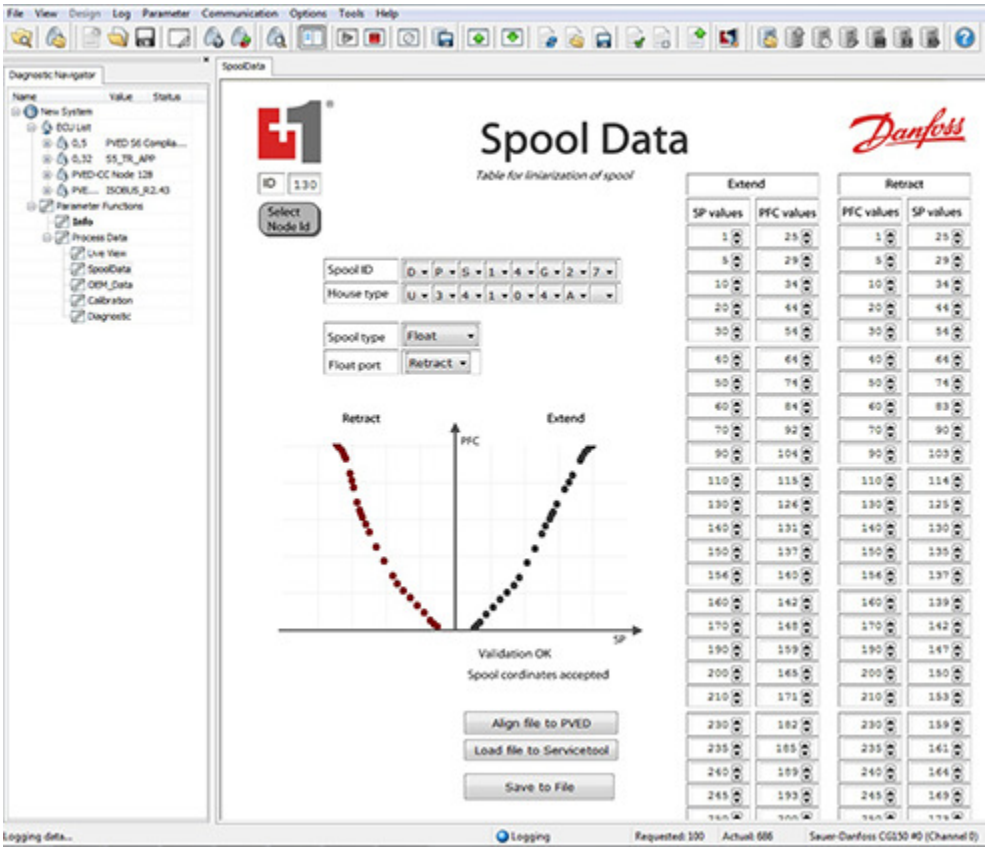
The KWP2000 max time defines maximum interval between messages.

- Basic parameters – OEM data – WebGPI, is activated by send
- Back up parameters –OEM Data – WebGPI activated and stored for next session
- Configurable: Range: 0 s – 255 s; Default value 5 s.

Spool curve

The spool curve defines relation between PFC in AVC and actual spool position in PVB. See also section Communication. J1939 defines an increment of the PFC by one gives a flow growth of 0.4% of max spool flow. Customization of the spool curve changes this ratio.

Data section



- Vertical is the flow command horizontal is the spool position.
- Vertical 1 refers to PFC 1 and horizontal 52 is PVBS (7 mm/250)*52 = 1.46 mm out of neutral.
- Vertical 250 is equal to flow 100%.

Float spools

For float spools Spool type Float opens menu to defines float direction by standard mounting. Float A is float in retract. Maximum flow (vertical 250) is at horizontal 196 (5.5 mm) and for PVBZ at horizontal 171 (4.8 mm). For software version 2.40 and newer float in both directions is supported for PVG 100.

Vertical 1 and vertical 250 must be present to avoid fault.

All values must be equal to or larger than the value to its left. Between two set of parameters (PFC vs position) linear interpolation is used.

Parameter setting is done with the service tool.

Warnings

PVED-CC warnings

Warning

Not applying to the Operational Conditions can compromise safety.

Depending on PVED-CC variant, age and software there are variations in communication and control. Read this technical information before implementing new PVED-CC in applications.

A PVG with PVED-CC can only perform according to the present descriptions if conditions in this Technical Information are met.

In particularly environmental exposed applications with PVE, protection in the form of a shield is recommended.

When the PVED-CC is in modes related to fault the validity of module reporting is limited by the fault type.

Deviation from recommended torque when mounting parts can harm performance and module.

Do not adjust the position transducer (LVDT) as this will influence calibration, and thus also safety and performance. This will also be the case by any damage or partial/full fixation of the LVDT.

All brands and all types of directional control valves – including proportional valves – can fail and cause serious damage. It is therefore important to analyze all aspects of the application. Because the proportional valves are used in many different operation conditions and applications, the machine builder/ system integrator alone is responsible for making the final selection of the products – and assuring that all performance, safety and warning requirements of the application are met.

When replacing the PVE, the electrical and the hydraulic systems must be turned off and the oil pressure released.

Protect persons and environment against oil spill. Hydraulic oil can cause both environmental damage and personal injuries.

Module replacement can introduce contamination and errors to the system. It is important to keep the work area clean and components should be handled with care.

The PVED-CC is not designed for use with voltage outside nominal for more than 5 minutes per hour and maximum 10% of operating time.

When the PVED-CC recognizes a fault it can enter fault mode and disable the operators control of the valve.

Obstacles for the Pilot oil can have direct influence on spool control.

Reduced pilot pressure will limit spool control.

Too high pilot pressure can harm the system.

When performing service. especially at temperatures below 0°C [32°F], avoid twisting and rough handling.

ISO 11783 CAN interface

Parameter setting

A number of parameters can be set for each valve using Process Data messages. (ISO11783-7 section B. 24)

Process data message

Transmission repetition rate	As conditions require		
Data length	8 bytes		
Data page	0		
PDU format	203		
PDU specific	Destination address (128 - 143 for valves 0 - 15)		
Default priority	3		
Parameter group no.	52096 (00CB8016)		
Message layout	Byte 1	Bit 8	Reserved (to be sent as '0' until further defined)
		Bits 7 - 6	Data format / error condition
		Bits 5 - 4	Process data type
		Bits 3 - 1	Process data type modifier
	Byte 2	Count number	
	Byte 3	Bits 8 - 5	Implement type
		Bits 4 - 1	Implement position
	Byte 4	Bits 8 - 5	Data dictionary row
		Bits 4 - 1	Data dictionary column
	Bytes 5 - 8	Process variable value	
Parameters	Process data type	00b = write	
		10b = read	
	Data dictionary row	6	

Process data message

Data dictionary Column		Default
0	Scaling extend, 0 - 250 (0 - 100 % in steps of 0.4 %)	250
1	Scaling retract, 0 - 250 (0 - 100 % in steps of 0.4 %)	250
2	Not used (Progressive /Degressive)	0
3	Slope extend, 0, 7, 13, 18, 25, 31, 37, 44, 49, 56, 61, 68, 77, 81, 88, 94	0
4	Dead band (Not used)	0
5	Dead band (Not used)	0
6	Slope retract, 0, 7, 13, 18, 25, 31, 37, 44, 49, 56, 61, 68, 77, 81, 88, 94	0
7	Not used (Progressive/Degressive)	0
8	Ramp up extend, 0 - 250 (0 - 4000 ms in steps of 16 ms)	0
9	Ramp down extend, 0 - 250 (0 - 4000 ms in steps of 16 ms)	0
A	Ramp up retract, 0 - 250 (0 - 4000 ms in steps of 16 ms)	0
B	Ramp down retract, 0 - 250 (0 - 4000 ms in steps of 16 ms)	0
C	Invert port, 0 (Off), 1 (ON)	0
D	Float threshold, 0 - 250 (0 - 100 % in steps of 0.4 %)	0

ISO 11783 CAN interface

To set 50 % scaling on the extend port, send this message to the valve:

ID	DLC	1	2	3	4	5	6	7	8
CCB8006	8	00	00	00	60	7D	00	00	00

To read scaling on the extend port, send this message to the valve:

ID	DLC	1	2	3	4	5	6	7	8
CCB8006	8	10	00	00	60	00	00	00	00

The valve will respond with:

ID	DLC	1	2	3	4	5	6	7	8
CCB8080	8	10	00	00	60	7D	00	00	00

Software ID

According to J1939/71, section 5.3.47

Software identification message

Transmission repetition rate	On request	
Data length	Variable	
Data page	0	
PDU format	254	
PDU specific	218	
Default priority	6	
Parameter group no.	65242 (00FEDA16)	
Messages layout	Byte 0	Number of fields (11)
	Byte 1...	SW version / ASCII * Delimiter
		Project name / ASCII * Delimiter
		Text information / ASCII * Delimiter
		Software part number / ASCII * Delimiter
		Hardware part number / ASCII * Delimiter
		HW Version / ASCII * Delimiter
		Build data / ASCII * Delimiter
		Build time / ASCII * Delimiter
		Host / ASCII * Delimiter
		Location / ASCII * Delimiter
		SW Label / ASCII * Delimiter
	Max. 185 bytes	

Component ID

According to J1939/71 section 5.3.25

Component identification message

Transmission repetition rate	On request
Data length	Variable
Data page	0
PDU format	254

ISO 11783 CAN interface

Component identification message (continued)

PDU specific	218		
Default priority	6		
Parameter group no.	65242 (00FEEB16)		
Message layout	Byte 1	ASCII * Delimiter	
	Bytes 2 - 9	Field b: Model	
	Bytes 10	ASCII * Delimiter	
	Bytes 10 - 20	Field c: Serial number	
	Bytes 21 - 22	ASCII * Delimiter	
Fields	Model	The according code of the PVED-CC	
	Serial number	Byte 1	Location: (Nordborg, DK)
		Byte 2	(Space)
		Bytes 3 - 4	Week of production
		Byte 5	Year of production
		Byte 6	Day of the week:
			A = Monday,
			G = Sunday
		Bytes 7 - 10	Running serial

The model and serial number fields are sent in ASCII.

Requesting PGN' s

Both Component ID and Software ID are requested using this message:

PGN request message

Transmission repetition rate	On request
Data length	8 bytes
Data page	0
PDU format	234
PDU specific	Destination adress (128 - 143 for valves 0 - 15)
Default priority	6
Parameter group no.	59904 (00EA0016)
Message layout	Bytes 1 - 3 requested PGN
	Bytes 4 - 8 not used

To request component ID, send this message to the valve.

ID	DLC	1	2	3	4	5	6	7	8
18EA8006	8	EB	FE	00	00	00	00	00	00

The component ID is returned using BAM/TP

	ID	DLC	1	2	3	4	5	6	7	8
BAM	1CECFF80	8	20	16	00	04	FF	EB	FE	00
			BAM	Bytes	Bytes	Packets	Res	PGN	PGN	PGN
DT 1	1CEBFF80	8	01	2A	31	35	37	58	30	39
			Seq	*	1	5	7	B	4	9

ISO 11783 CAN interface

The component ID is returned using BAM/TP (continued)

	ID	DLC	1	2	3	4	5	6	7	8
DT 2	1CEBFF80	8	02	37	35	2A	4E	20	35	31
			Seq	4	2	*	N	space	5	1
DT 3	1CEBFF80	8	03	31	43	30	30	30	31	2A
			Seq	1	C	0	0	0	1	*
DT 4	1CEBFF80	8	04	2A	FF	FF	FF	FF	FF	FF
			Seq	*						

Component ID extracted from message: *157B4942*N 511C0001**

Fault mode

If the PVED-CC detects a failure, it will send a DM1 within the next 20 ms and if defined, also disables the solenoid valves.

DM1 Error message (J1939/73 Section DM1)

Transmission repetition rate	On request			
Data length	8 bytes			
Data page	0			
PDU format	254			
PDU specific	202			
Default priority	6			
Parameter group no.	65226 ($00FECA_{16}$)			
Message layout	Byte 1	Lamp		
	Byte 2	Reserved (FF)		
	Byte 3 - 5	SPN/FMI		
	Byte 6	Occurrence counter		
	Byte 7 - 9	SPN/FMI		
	Byte 10	Occurrence counter		
Details		Lamp	Bits 8 - 7	Malfunction lamp status
			Bits 6 - 5	Red stop lamp status
			Bits 4 - 3	Amber warning lamp status
			Bits 2 - 1	Protect lamp status
		SPN/FMI	Bits 24 - 6	SPN
			Bits 5 - 1	FMI

If one error has been detected, the valve sends

ID	DLC	1	2	3	4	5	6	7	8
18FECA80	8	Lamp	Res	SPN1	SPN2	SPN3/FMI	OC	FF	FF

If more than one error is active BAM/TP is used for transmission. For more details, see the chapter *Error codes*.

	ID	DLC	1	2	3	4	5	6	7	13,566
BAM	1CECFF80	8	20	16	00	04	FF	CA	FE	00
			BAM	Bytes	Bytes	Packets	Res	PGN	PGN	PGN
DT 1	1CEBFF80	8	01	Lamp	Reserved	SPN1	SPN2	SPN3/FMI	OC	SPN1
			Seq							

ISO 11783 CAN interface

	ID	DLC	1	2	3	4	5	6	7	13,566
DT 2	1CEBFF80	8	02	SPN2	SPN3/FMI	OC	SPN1	SPN2	SPN3/FMI	OC
			Seq							
DT 3	1CEBFF80	8	03	SPN1	SPN2	SPN3/FMI	OC	SPN1	SPN2	SPN3/FMI
			Seq							
DT 4	1CEBFF80	8	04	ON	FF	FF	FF	FF	FF	FF
			Seq	*						

The errorlog of the PVED-CC is read by requesting the correct PGN. The returned data has the same format as DM1 (J1939/79 Section DM2).

Error message

Transmission repetition rate	On request		
Data length	8 bytes		
Data page	0		
PDU format	254		
PDU specific	203		
Default priority	6		
Parameter group no.	65227 (00FECB16)		
Message layout	Byte 1	Lamp	
	Byte 2	Reserved (FF	
	Byte 3 - 5	SPN/FMI	
	Byte 6	Occurrence counter	
	Byte 7 - 9	SPN/FMI	
	Byte 10	Occurrence counter	
Details		Lamp	Bits 8 - 7	Malfunction lamp status
			Bits 6 - 5	Red stop lamp status
			Bits 4 - 3	Amber warning lamp status
			Bits 2 - 1	Protect lamp status
		SPN/FMI	Bits 24 - 6	SPN
			Bits 5 - 1	FMI

To clear the errorlog request the PGN below. The PVED-CC will not respond, but the result can be checked using DM2 (J1939/73 Section DM3).

Error message

Transmission repetition rate	On request
Data length	8 bytes
Data page	0
PDU format	254
PDU specific	204
Default priority	6
Parameter group no.	65228 ($00FECC_{16}$)

State machine and operational modes

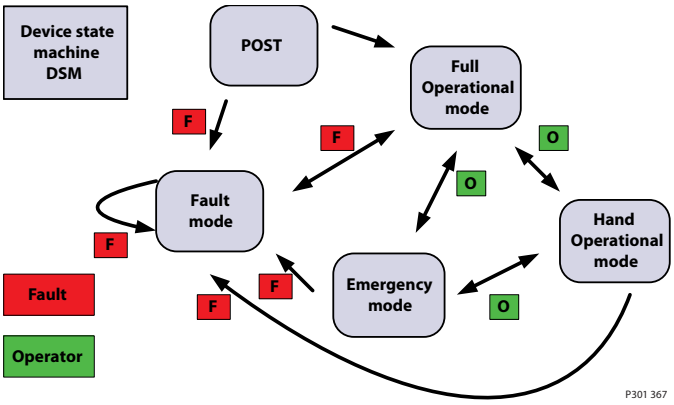
After power up, the PVED-CC will go through the following sequence

- Power On Self Test (POST)
- Initialise communication
- Issue Address Claim CAN message
- Go into operational mode
- Start sending out Auxiliary Valve Estimated Flow messages (AVEF)
- Start listening for Auxiliary Valve Command (AVC) and Process Data (PD)

The AVEF will be send from the PVED as long as it is Transmitting

On the macro level the PVED-CC is driven by a state machine where state changes are driven by operator choice or fault condition with two exceptions.

Device state machine diagram (DSM)



Power On Self Test

When the PVED-CC is powered a series of tests are performed before operation start.

- Code CRC is calculated and compared with stored value
- Internal signals are evaluated
- EEPROM stored parameters are compared
- Spool position is evaluated.

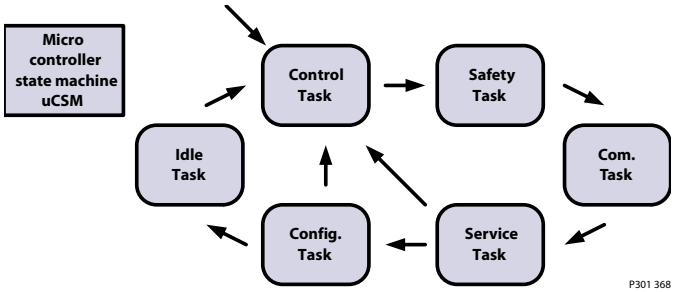
uCSM

Short walk through of PVED operation:

After the POST the embedded system starts to follow a 10 millisecond rhythm. Every 10 ms the control task starts. This Microcontroller State Machine (uCSM) defines interaction between valve and system master.

State machine and operational modes

MC state machine diagram(uCSM)



- Control Task defines set point for the ASIC. Initial value is blocked
- Safety Task verify system state and enable solenoids if allowed and needed
- Communication Task reads communication in buffers and writes to communication out buffers. CAN signal handling
- Service Task evaluate changes in settings if required by system master
- Configuration Task writes to memory
- Idle Task waits for next 10 ms tic

AVEF

The valve will send out an Axillary Valve Estimated Flow (AVEF) message (ISO11783-7 section B.11) based on the average spool position during the last 80ms. Frequency is by default 1/100ms. Value is configurable.

In the present software the message is extended to eight byte.

ID	DLC	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7	Byte 8
CFE1080	8	Extend	Retract	State	SD mode	SD PWM	SD SP ASIC	SD SP Ctrl	SD temp

AVEF interpretation

Extend. Estimated percentage of maximum flow as an averaged over 80 ms calculated on basis of the spool curve with an off set of 125.

Estimated flow in extend

Estimated flow in extend	Value in DEC	Value in HEX
0 %	125	7D
25%	150	96
100%	225	E1

Retract. Estimated percentage of maximum flow as an averaged over 80 ms calculated on basis of the spool curve with an off set of 125.

State. Four bits are used for indication. Only these values are legal.

State

State	Blocked	Extend	Retract	Float	Fault
Indicator	0	1	2	3	14

SD mode uses bit setting in this pattern XPMMHHLA.

State machine and operational modes

SD mode pattern XPMMHHLA

Parameter	Indicates	Combination	Interpretation
X	Hand operational	0/1	Disabled/Enabled
P	Toggle mode	0/1	De-energized/energized
MM	Solenoid control	00	Energized
		01	Power Save (not in 2.60)
		10	Disabled
		11	Reserved
HH	Print board	00	Reserved
		01	Old PCB
		10	PCB with temperature sensor and extra LVDT monitoring
		11	Reserved
L	LVDT fault	0/1	False/True
A	ASIC error pin	0/1	False/True

- L and A are the internal signals not an indication of the module fail mode.
  By False no fault is present.
- 0x08 (00001000) Normal operation with activated solenoids, new PCB
- 0x18 (00011000) Normal operation in Power Save, new PCB
- 0xA4 (10100100) Hand operational, solenoids disabled, old PCB, LVDT OK, ASIC OK

SD PWM is the control signal send from microcontroller to closed loop control. Resolution is 0.8 pct of spool travel. Value is not filtered.

Set point	Value in DEC	Value in HEX
- 7 mm (retract)	0	0
- 1,4 mm	100	64
Blocked	125	7D
+ 7 mm	250	FA

SP ASIC is the spool position calculated by the ASIC. Value is not filtered and not adjusted to module calibration.

SP CTRL is the spool position calculated by the microcontroller based on direct LVDT feedback to microcontroller. Value is not filtered and not adjusted to module calibration/Value is fixed as 0xFE in SW 2.60 and if old PCB is used.

Spool position	Value in DEC	Value in HEX
- 7 mm (retract)	0	0
- 1.4 mm	100	64
Blocked	125	7D
+ 7 mm	250	FA

SD temp is the instant value for PCB temperature. Resolution is 1 oC. Value is not filtered/Value is fixed as 0xFE in SW 2.60 or if old PCB is used.

Temperature	Value in DEC	Value in HEX
-40 °C [-40 °F]	10	0A
0 °C [32 °F]	50	32
100 °C [212 °F]	150	64
200 °C [392 °F]	250	C8

State machine and operational modes

Flow is 0 % when state is float. Flow above 0 % in extend and retract at the same time is fault.
SD parameters are proprietary use of the AVEF message and can be ignored.
The SD PWM, SD SP ASIC and SD SP CTRL are used for spool monitoring.
If spool is further out than 'Fault Limit' for more than GTO, a fault is raised.

Warning

The limitation on operating temperature is still valid. Average working temperature above 85 °C [185 °F] and peek temperature above 100 °C [212 °F] can harm electronic components.

Interpretation with software version 2.4 and older

In PVED-CC with software version 2.40 and older this format is used.

Auxiliary valve 0 estimated flow

Transmission repetition rate	100 ms		
Data length	8 bytes		
Data page	0		
PDU format	254		
PDU specific	16 (16 - 31 for valves 0 - 15)		
Default priority	3		
Parameter group no.	65040 (00FE1016)		
Message layout	Byte 1	Estimated flow extend	
	Byte 2	Estimated flow retract	
	Byte 3	Bits 8 - 7	Fail safe mode
		Bits 6 - 5	Reserved
		Bits 4 - 1	Valve state
	Bytes 4 - 8	Reserved	
Parameters	Estimated flow	Estimated flow as percentage of maximum available flow.	
		Resolution	1 % / bit
		Offset	125 %
		Range	-125 % - 125 %
	Operating mode	Valve state	
		0 Blocked	
		1 Extend	
		2 Retract	
		3 Floating	
		14 Error indication	

The PVED-CC will only estimate positive flow, ie. out of the port.

If the spool has moved to 50% flow out of the retract port, the valve sends this message:

ID	DLC	1	2	3	4	5	6	7	8
CFE1080	8	7D	AF	02	00	00	00	00	00

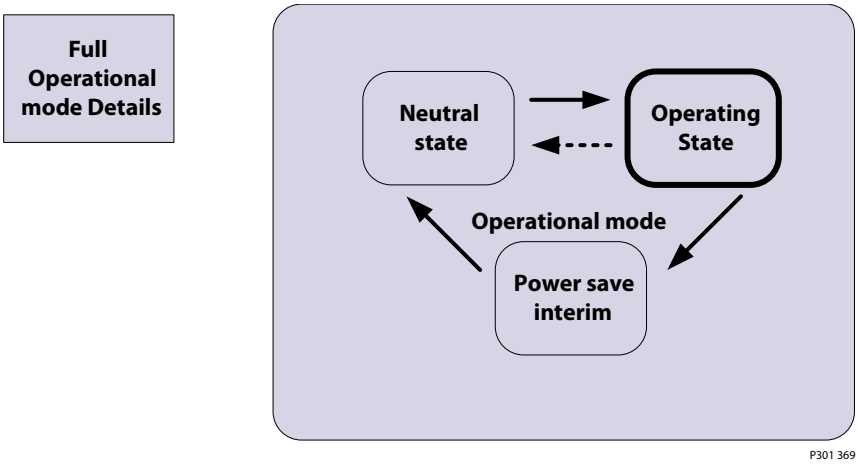
The "Error Indication" in the valvestate field will be used if the µP detects servere faults in LVDT wiring, memory or internal computation.

State machine and operational modes

Full operational mode

On the macro level the Full Operational Mode is the default. This is when no faults are present and no special commands are given. In this Mode the operator has full control and controllability of the valve via the system control devices.

Full operational mode diagram



When PVED is unpowered or in power save mode the main spool is kept in blocked/ neutral position by the neutral spring. By use of the handle (PVM) or the solenoid valves and the Pp the spool can be moved to any position and so open for system pressure to the application.

Closed loop

ASIC: Solenoid control is run at 40Hz in operation mode Full Operational

Solenoid valve control is deactivated in power save. Monitoring is still active.

Spool positioning

- Extend is defined as spool moving away from PVE and equals positive values.
- Retract is defined as spool moving towards PVE and equals negative values.

Flow control

In Full Operational mode the PVED-CC responds to Auxiliary valve command - AVC. To control the PVED-CC, send AVC messages to it. (ISO11783-7 section B.13)

Auxiliary valve command (AVC)

Transmission repetition rate	Maximum rate of 1 second between messages for each valve or when a parameter is required to change state. Minimum rate of 10 ms
Data length	8 bytes
Data page	0
PDU format	254
PDU specific	48 (48 - 63 for valves 0 - 15)
Default priority	3
Parameter group no.	65072 (00FE3016)

State machine and operational modes

Auxiliary valve command (AVC) (continued)

Message layout	Byte 1	PFC	
	Byte 2	Reserved	
	Byte 3	Bits 8 - 7	Fail safe mode (ignored, always in blocked)
		Bits 6 - 5	Reserved
		Bits 4 - 1	Valve state
	Bytes 4 - 8	Reserved	
Parameters	PFC	Wished flow as percentage of maximum available flow.	
		Resolution	0.4 % / bit
		Offset	0%
		Range	0 - 100%
	Operating mode	Valve state	
		0 Blocked	
		1 Extend	
		2 Retract	
		3 Floating	
		Fail safe mode	
		0 Blocked	

AVC Aux. Valve command

PD Process data

PFC Port flow command

BAM Broadcast announce message

AUX. Valve estimated flow

TP Transport protocol

The valve checks messages for coherency and if a message is not correct, the valve will go to blocked and an error message will be issued. To set a flow in a port, the 1st byte must be non-zero and the second must be zero. To go to float, both 1st and 2nd bytes must be zero. If a float threshold is active the previous message must have left the valve in retract above the threshold.

To set 50% flow out of the Retract port, send this message to the valve:

ID	DLC	1	2	3	4	5	6	7	8
CFE3006	8	7D	00	02	00	00	00	00	00

Hand operational mode

The possibility to enter a Hand Operational mode is now implemented. This mode de-energize the solenoid valves, disables spool position fault monitoring and AVC time out. This mode is not covered by the ISO 11783 part 7.

Benefits are:

- Hydraulics do not work against the PVM
- No spool position fault is recorded
- Application controller does not have to send set points
- Estimated Flow is still reported to system
- Remaining safety functions in PVED are still active.

State machine and operational modes

To enter Hand Operational mode use the Auxiliary Valve Command (AVC) with port flow 0 % and valve state 10.

ID	DLC	Byte 1 PFC	Byte 2 reserved	Byte 3 state	Byte 4	Byte 5	Byte 6	Byte 7	Byte 8
CFE3006	8	0	0	A	0	0	0	0	0

Enter Hand Operational mode for node 128 (0x80).

To leave Hand Operational mode use the Auxiliary Valve Command (AVC) Blocked.

ID	DLC	Byte 1 PFC	Byte 2 reserved	Byte 3 state	Byte 4	Byte 5	Byte 6	Byte 7	Byte 8
CFE3006	8	0	0	0	0	0	0	0	0

Leave Hand Operational mode for node 128 (0x80).

Leaving Hand Operational mode will not activate the jitter.

Emergency stop

Gives blocked set point and overrules any ramping

This mode is not covered by the ISO 11783 part 7.

To enter Emergency Stop use the Auxiliary Valve Command (AVC) with port flow 0 % and valve state 14.

ID	DLC	Byte 1 PFC	Byte 2 reserved	Byte 3 state	Byte 4	Byte 5	Byte 6	Byte 7	Byte 8
CFE3006	8	0	0	E	0	0	0	0	0

Start Emergency Stop for node 128 (0x80).

To disable Emergency Stop use the Auxiliary Valve Command (AVC) Blocked.

ID	DLC	Byte 1 PFC	Byte 2 reserved	Byte 3 state	Byte 4	Byte 5	Byte 6	Byte 7	Byte 8
CFE3006	8	0	0	0	0	0	0	0	0

Disable Emergency Stop for node 128 (0x80).

AVEF for node 128 (0x80).

Error description

Error code walk through

The PVED-CC can detect a number of events that can be seen as faults and will categorize them into error codes (DM). Any of these events will raise a flag in the microcontroller and when the uCSM enters the safety task a system reaction follows.

Non-expected event

- Safety Task counts until threshold value
- If temporary or permanent fault ASIC solenoid enable is disabled (smart reaction is a special case)
  - By Warning, Temporary and Permanent a DM1 is sent
  - Error counter is added one up.

System is kept in this state for the minimum time depending on SW version.

If the state is still present after one second the DM1 is resend. If more than two fault are present a Broadcast Announce Message (BAM) is used. During fault state the system, limited by present faults, still monitors for additional faults.

Recovery

Recovery depends on fault category.

Recovery

Warning	Operation is maintained as before warning was sent.
Temporary	When fault condition disappears and two AVC Blocked are sent operation can be recontinued.
Permanent	A reboot is required to start operation.
Temporary/permanent	Recovery depends on monitoring and recovery mode defined in OEM settings.

Settings

A number of OEM settings has influence on the fault monitoring.

General timeout (GTO)

The GTO is the time limit a filtered fault must be present before it is recognized as a fault.

Float timeout (FTO)

As the GTO but only for entering and leaving float.

Auxiliary valve timeout (AVCTO)

The AVCTO works as a watchdog on the controller AVC. The setting can be from 0 to 65535 ms in step of 10 ms. Setting 0 ms disables timeguarding, meaning last received set point is always valid. AVCTO functionality is also defined by SW ver.

Power save (OEM)

Read section on software version variants

Spool curve

Dead band setting and float availability influences fault entering

Error description

Float available (spool)

A spool without float cannot be sent to float.

Warning

The spool with float must have a spool curve for float to avoid unintended float.

Error codes

- SPN means **Suspect Parameter Number**. Reference to the SAE J1939.
- FMI means **Failure Mode Indicator**
- Number in brackets is the message sent.
- Index is the Danfoss fault identification.

1's complement redundancy test

SPN	299007
FMI	12, {0xFF, 0x8F, 0x8C} index 0
Cause	An internal error in the PVED-CC's RAM occurred
Error	Permanent. This error requires reboot to restore CAN control.
Solution	Turn the ignition key off and back on

If the fault code is repeated (the fault code is increased by 1), the PVED-CC should be replaced.

1st boot

SPN:	299006
FMI:	12, {0xFE, 0x8F, 0x8C} index 1.
Cause:	Reserved for internal use.
Solution:	Not available. By reoccurrences you must contact your dealer.

Reserved

SPN:	299005
FMI:	0, {0xFD, 0x8F, 0x80} index 2.
Cause:	Reserved for internal use.
Solution:	Not available. By reoccurrences you must contact your dealer.

Division by zero

SPN:	299004
FMI:	11, {0xFC, 0x8F, 0x8B} index 3.
Cause:	This is an internal software error.
Error:	Permanent. This error requires reboot to restore CAN control.
Solution:	Cycle power. If the error is repeated replace the PVED-CC

CapCom values

SPN:	299003
FMI:	11 {0xFB, 0x8F, 0x8B} index 4.
Cause:	This is an internal software error.
Error:	Permanent. This error requires reboot to restore CAN control.

Error description

Solution:	Cycle power. If the error is repeated replace the PVED-CC

Variable truncation

SPN:	299002
FMI:	11 {0xFA, 0x8F, 0x8B} index 5
Cause:	This is an internal software error.
Error:	Permanent. This error requires reboot to restore CAN control.
Solution:	Cycle power. If the error is repeated replace the PVED-CC

Verified write to cell error

SPN:	299001
FMI:	12 {0xF9, 0x8F, 0x8C} index 6
Cause:	This error indicates an error in the parameter storage.
Error:	Permanent. This error requires reboot to restore CAN control.
Solution:	Cycle power. If the error is repeated replace the PVED-CC

Reserved

SPN:	298969
FMI:	0, {0xD9, 0x8F, 0x80} index 7.
Cause:	Reserved for internal use.
Error:	Permanent. This error requires reboot to restore CAN control.
Solution:	Not available. By reoccurrences you must contact your dealer.

Interpolation check

SPN:	298968,
FMI:	11, {0xD8, 0x8F, 0x8B} index 8.
Cause:	Reserved for internal use.
Error:	Permanent. This error requires reboot to restore CAN control.
Solution:	Not available. By reoccurrences you must contact your dealer.

Estimate calibration values error

SPN:	299000
FMI:	13, {0xF8, 0x8F, 0x8D} index 9.
Cause:	Reserved for internal use.
Error:	Permanent. This error requires reboot to restore CAN control.
Solution:	Not available. By reoccurrences you must contact your dealer.

PWM calibration values error

SPN:	298999
FMI:	13, {0xF7, 0x8F, 0x8D} index 10.
Cause:	Reserved for internal use.
Error:	Permanent. This error requires reboot to restore CAN control.
Solution:	Not available. By reoccurrences you must contact your dealer.

Error description

Mechanical Spool Compensation values

SPN:	298998
FMI:	13, {0xF6, 0x8F, 0x8D} index 11.
Cause:	Incorrect Spool Data Values were sent to the PVED-CC. The values were rejected. This will never happen during normal operation.
Error:	Permanent. This error requires reboot to restore CAN control.
Solution:	Review and correct the Spool Data that is sent to the PVED.

Reserved

SPN:	298997
FMI:	0, {0xF5, 0x8F, 0x80} index 12.
Cause:	Reserved for internal use.
Error:	Permanent. This error requires reboot to restore CAN control.
Solution:	Not available. By reoccurrences you must contact your dealer.

Spool data and Float available

SPN:	298996,
FMI:	2, {0xF4, 0x8F, 0x82} index 13.
Cause:	An attempt was made to program the PVED with Spool Data that indicate that a float position is available, but the curve also extends into the float position. This will never happen during normal operation.
Error:	Temporary. To restore control send two consecutive Blocked commands.
Solution:	Review and correct the Spool Data that is sent to the PVED.

Reserved

SPN:	298967,
FMI:	0, {0xD7, 0x8F, 0x80} index 14.
Cause:	Reserved for internal use.
Error:	Permanent. This error requires reboot to restore CAN control.
Solution:	Not available. By reoccurrences you must contact your dealer.

Reserved

SPN:	298966,
FMI:	0, {0xD6, 0x8F, 0x80} index 15.
Cause:	Reserved for internal use.
Error:	Permanent. This error requires reboot to restore CAN control.
Solution:	Not available. By reoccurrences you must contact your dealer.

CRC16 check / Parameter memory

SPN:	630
FMI:	12, {0x76, 0x02, 0x0C} index 16.
Cause:	At saving values to the EEPROM an error occurred. This can be due to a bad cell.
Solution:	Turn power off and on, wait 20 sec, turn power off and on and check if the message SPN 298994 FMI 11 comes up. Now EEPROM data should be updated with approved data.

By reoccurrences modules must be replaced.

Error description

Fall back to old values

SPN:	298995
FMI:	11, {0xF3, 0x8F, 0x8B} index 17.
Cause:	There was an error during CRC16 check of parameter memory, because power was removed at the saving time, and the PVED-CC uses the back up.
Warning.	You have full control of the PVED.
Solution:	If you have tried to change settings you must repeat.

CRC16 check / Program memory

SPN:	628
FMI:	12, {0x74, 0x02, 0x0C} index 18.
Cause:	A CRC 16 check was made on the software image and saved in the flash. A CRC 16 check is made on the flash every 10 s and compared. If they do not match this message will be sent out.
Error:	Permanent. This error requires reboot to restore CAN control.
Solution:	Replace the PVED-CC.

Main spool cannot reach neutral from retract

Only accessible in service tool. index 19. Errors recorded here are for DM1 and DM2 counted with index 26.

In software version 2.40 and older was:

ASIC supervision of CL control

SPN:	298965, FMI: 12, {0xD5, 0x8F, 0x8C} index 19.
Cause:	The internal electronics (ASIC) in the PVED has reported an error to the microcontroller.
Temporary error.	Depending on Fault monitoring mode the control of the PVED is regained when the error disappears.
Solution:	Not available. By reoccurrences you must replace PVED-CC.

LVDT wiring error

SPN:	298994
FMI:	12, {0xF2, 0x8F, 0x8C} index 20.
Cause:	The LVDT feed back is too high or to low. This could be caused by the LVDT put to an extreme position, a short circuited connection to the LVDT or a broken a broken connection.
Error:	Permanent. This error requires reboot to restore CAN control.
Solution:	Replace the PVED-CC.

Power supply above specified range

SPN:	627
FMI:	3, {0x73, 0x02, 0x03} index 21.
Cause:	The power supply is above 32 volt
Error:	Temporary. Depending on Fault monitoring mode the control of the PVED is restored when the error disappears and the PVED has received two consecutive Blocked commands.
Solution:	Lower the voltage to 30 volt and the error will disappear.

Power supply below specified range

SPN:	627
FMI:	4, {0x73, 0x02, 0x04} index 22.

Error description

Cause:	The power supply is below 10 volt
Error:	Temporary. Depending on Fault monitoring mode the control of the PVED is restored when the error disappears and the PVED has received two consecutive Blocked commands.
Solution:	Increase the voltage to 11 volt and the error will disappear.

No answer on handshakes

SPN:	298993
FMI:	11, {0xF1, 0x8F, 0x8B} index 23.
Cause:	The supervisor is not working correctly, or the microcontroller has stopped sending handshakes to the supervisor.
Error:	Permanent. This error requires reboot to restore CAN control.
Solution:	Turn the ignition key off and back on, if the fault code is repeated (the fault counter is increased by 1), the PVED-CC should be replaced.

Power-on self test failed

SPN:	298992
FMI:	12, {0xF0, 0x8F, 0x8C} index 24.
Cause:	The supervisor did not start up correctly.
Error:	Permanent. This error requires reboot to regain CAN control.
Solution:	Turn the ignition key off and back on, if the fault code is repeated (the fault counter is increased by 1), the PVED-CC should be replaced.
Special case:	Error can occur by download of software. If power is kept on after download the microcontroller reactivates. As the PVED has not been rebooted the electronic is not reset, this causes the error.

Time value for CL control out of range

SPN:	298964,
FMI:	2, {0xD4, 0x8F, 0x82} index 25.
Cause:	Reserved for internal use.
Error:	Temporary. To restore CAN control send two consecutive Blocked commands.
Solution:	Not available. By reoccurrences you must contact your dealer.

Main spool cannot reach neutral

SPN:	298991
FMI:	7, {0xEF, 0x8F, 0x87} index 26.
Cause:	The spool is stuck in some position outside neutral position, and the PVED-CC cannot move it back to neutral. The PVED-CC disables the solenoids so the spool should be returned to neutral position by the spring.
Error:	Temporary. Depending on Fault monitoring mode the control of the PVED is restored when the error disappears and the PVED has received two consecutive Blocked commands.
Solution:	Check for dirt in the mechanical part of the valve, especially around the spool. There is also a filter at the pilot oil inlet of the PVED-CC that may be blocked. If this does not help, replace the PVED-CC.

For DM1 and DM2 this SPN covers index 19 + index 26.

In service tool index 26 covers “Main spool cannot reach neutral from extend”.

Main spool cannot reach float position

SPN:	298990
FMI:	7, {0xEE, 0x8F, 0x87} index 27.

Error description

Cause:	The spool cannot go all the way to 7 mm stroke.
Error:	Temporary. Depending on Fault monitoring mode the control of the PVED is restored when the error disappears and the PVED has received two consecutive Blocked commands.
Solution:	Check for dirt in the mechanical part of the valve, especially around the spool. There is also a filter at the pilot oil inlet of the PVED-CC that may be blocked. If this does not help, replace the PVED-CC.

Main spool not in neutral at boot up

SPN:	298989
FMI:	7, {0xED, 0x8F, 0x87} index 28.
Cause:	The spool must be in neutral at boot up. If the PVED-CC is powered up, but not mounted on the valve house, or if it is mounted, but does not have Spool parameters downloaded, the spool will not be in neutral.
Error:	Temporary. Depending on Fault monitoring mode the control of the PVED is restored when the error disappears and the PVED has received two consecutive Blocked commands.
Solution:	Mount the PVED-CC on the valve house, and make sure there is no dirt between the pin and the spool. Turn power back on and see if the message occurs again. If it does, download spool parameters to the valve, turn off/on. If there still is an error, replace the PVED-CC.

Main spool position is greater than the reference

SPN:	298988
FMI:	7, {0xEC, 0x8F, 0x87} index 29.
Cause:	The spool has moved further out than intended.
Error:	Temporary. Depending on Fault monitoring mode the control of the PVED is restored when the error disappears and the PVED has received two consecutive Blocked commands.
Solution:	Power off and on. If the error is repeated, replace the PVED-CC.

Main spool position and reference are in opposite directions

SPN:	298987
FMI:	7, {0xEB, 0x8F, 0x87} index 30.
Cause:	After a change in set point, the spool must move to the direction of the new set point. If the spool is in the wrong direction after the set fault monitoring delay this error is issued.
Error:	Temporary. Depending on Fault monitoring mode the control of the PVED is restored when the error disappears and the PVED has received two consecutive Blocked commands.
Solution:	Change to oil with a higher viscosity, set a limitation to the spool stroke or/and change the fault monitoring delay.

If the error is repeated with oil at 20 cS replace the PVED-CC.

Float threshold has not been passed

SPN:	298986
FMI:	7, {0xEA, 0x8F, 0x87} index 31.
Cause:	A Port Flow Command to go to floating position was issued when the spool had not moved outside the float threshold.
Error:	Temporary. Depending on Fault monitoring mode the control of the PVED is restored when the error disappears and the PVED has received two consecutive Blocked commands.
Solution:	Let the spool move outside the float threshold before issuing the floating position command or change the float threshold value.

Time guarding on Auxiliary Valve Command

SPN:	298985

Error description

FMI:	19, {0xE9, 0x8F, 0x93} index 32.
Cause:	A new set point was not received within the time specified by the Aux Valve Timeout setting. For version 2.40 and newer Time guarding is only working after first valid AVC and with valve not in blocked.
Error:	Temporary. Depending on Fault monitoring mode the control of the PVED is restored when the error disappears and the PVED has received two consecutive Blocked commands.
Solution:	Send set points more often or increase the time-out value.

Illegal CAN address

SPN:	298984
FMI:	2, {0xE8, 0x8F, 0x82} index 33.
Cause:	An attempt was made to change the CAN ID of the PVED-CC to an illegal value.
Error:	Warning. You have full control of the PVED.
Solution:	Use a legal CAN ID. CAN IDs 128 [0x80] to 143 [0x8F] are available.

Command out of range

SPN:	298983
FMI:	2, {0xE7, 0x8F, 0x82} index 34.
Cause:	A Port Flow Command with a flow of more than 250 was received.
Error:	Warning. You have full control of the PVED.
Solution:	Send commands that don't exceed 250.

Scaling error

SPN:	298982
FMI:	2, {0xE6, 0x8F, 0x82} index 35.
Cause:	A Process Data or WebGPI value for scaling was larger than 250.
Error:	Warning. You have full control of the PVED.
Solution:	Set scaling to maximum 250.

Ramps error

SPN:	298981
FMI:	2, {0xE5, 0x8F, 0x82} index 36.
Cause:	A Process Data or WebGPI value for ramps was larger than 250.
Error:	Warning. You have full control of the PVED.
Solution:	Set ramps to maximum 250.

Float threshold error

SPN:	298980
FMI:	2, {0xE4, 0x8F, 0x82} index 37.
Cause:	A Process Data or WebGPI value for float threshold was larger than 250.
Error:	Warning. You have full control of the PVED.
Solution:	Set float threshold to maximum 250.

Dead band compensation error

SPN:	298979
FMI:	2, {0xE3, 0x8F, 0x82} index 38.

Error description

Cause:	A spool data value was not within defined range.
Error:	Warning. You have full control of the PVED.
Solution:	Send valid parameters

Slope error

SPN:	298978
FMI:	2, {0xE2, 0x8F, 0x82} index 39.
Cause:	A Process Data or WebGPI value for slope was not one the 16 predefined values.
Error:	Warning. You have full control of the PVED.
Solution:	Use one of: 0, 7, 13, 18, 25, 31, 37, 44, 49, 56, 61, 68, 77, 81, 88, and 94. Each number represents an increasingly progressive curve.

Shape error

SPN:	298977
FMI:	2, {0xE1, 0x8F, 0x82} index 40.
Cause:	Reserved for future use.

Invert port error

SPN:	298976
FMI:	2, {0xE0, 0x8F, 0x82} index 41.
Cause:	A Process Data or WebGPI command was sent to invert the ports, but this is not allowed, if the spool has a floating position available.
Error:	Warning. You have full control of the PVED.
Solution:	You cannot invert ports.

Illegal combination of Port Flow Command and Blocked state

SPN:	298975
FMI:	2, {0xDF, 0x8F, 0x82} index 42.
Cause:	You are not allowed to set a Port Flow >0 if the valve state command is Blocked (0)
Error:	Temporary. Depending on Fault monitoring mode the control of the PVED is restored when the error disappears and the PVED has received two consecutive Blocked commands.
Solution:	Set Port Flow to 0 if the wished state is Blocked.

Illegal combination of Port Flow Command and Float state

SPN:	298974
FMI:	2, {0xDE, 0x8F, 0x82} index 43.
Cause:	You are not allowed to set a Port Flow >0 if the valve state command is Float (3)
Error:	Temporary. Depending on Fault monitoring mode the control of the PVED is restored when the error disappears and the PVED has received two consecutive Blocked commands.
Solution:	Set Port Flow to 0 if the wished state is Float.

Port flow command above 100%

SPN:	298973
FMI:	2, {0xDD, 0x8F, 0x82} index 44.
Cause:	A Port Flow Command with a flow of more than 100% (250) was received.

Error description

Error:	Temporary. Depending on Fault monitoring mode the control of the PVED is restored when the error disappears and the PVED has received two consecutive Blocked commands.
Solution:	Don't send commands that exceed 100% (250).

Illegal valve state

SPN:	298972
FMI:	2, {0xDC, 0x8F, 0x82} index 45.
Cause:	An Auxiliary Valve Command with an undefined state was received.
Error:	Temporary. Depending on Fault monitoring mode the control of the PVED is restored when the error disappears and the PVED has received two consecutive Blocked commands.
Solution:	Only send commands with one of: Blocked (0), Extend (1), Retract (2) or Float (3).

Illegal valve state and illegal port flow command

SPN:	298971
FMI:	2, {0xDB, 0x8F, 0x82} index 46.
Cause:	An illegal command was send from the controller.
Error:	Temporary. Depending on Fault monitoring mode the control of the PVED is restored when the error disappears and the PVED has received two consecutive Blocked commands.
Solution:.	Only send commands with values PFC; 0 – 250 and State; 0 – 3.

Illegal combination of inverted ports and float properties

SPN:	298970
FMI:	2, {0xDA, 0x8F, 0x82} index 47.
Cause:	A Process Data or WebGPI command was sent to invert the ports, but this is not allowed, if the spool has a floating position available.
Error:	Temporary. Depending on Fault monitoring mode the control of the PVED is restored when the error disappears and the PVED has received two consecutive Blocked commands.
Solution:	You cannot invert ports.

Errors overview table

Errors overview

Index	CAN Value	SPN / FMI	Designation	Fault Status
0	0xFF 0x8F 0x8C	SPN=299007 / FMI=12	RAM: 1's complement redundancy test	Permanent
1	0xFE 0x8F 0x8C	SPN=299006 / FMI=12	EEPROM: First boot	Permanent
2	0xFD 0x8F 0x80	SPN=299005 / FMI=0	Reserved for future use	Reserved
3	0xFC 0x8F 0x8B	SPN=299004 / FMI=11	CALCULATION: Division by zero	Permanent
4	0xFB 0x8F 0x8B	SPN=299003 / FMI=11	CALCULATION: CapCom values	Permanent
5	0xFA 0x8F 0x8B	SPN=299002 / FMI=11	CALCULATION: Variable truncation	Permanent
6	0xF9 0x8F 0x8C	SPN=299001 / FMI=12	EEPROM: Verified write to cell	Permanent
7	0xD9 0x8F 0x80	SPN=298969 / FMI=0	Reserved for future use	Reserved
8	0xD8 0x8F 0x8B	SPN=298968 / FMI=11	CALCULATION: Interpolation Check	Permanent
9	0xF8 0x8F 0x8D	SPN=299000 / FMI=13	VALIDATION: Estimate calibration values	Permanent
10	0xF7 0x8F 0x8D	SPN=298999 / FMI=13	VALIDATION: PWM calibration values	Permanent
11	0xF6 0x8F 0x8D	SPN=298998 / FMI=13	VALIDATION: Spool Data	Permanent
12	0xF5 0x8F 0x80	SPN=298997 / FMI=0	Reserved for future use	Reserved
13	0xF4 0x8F 0x82	SPN=298996 / FMI=2	VALIDATION: Spool data and Float Available	Permanent
14	0xD7 0x8F 0x80	SPN=298967 / FMI=0	Reserved for future use	Reserved

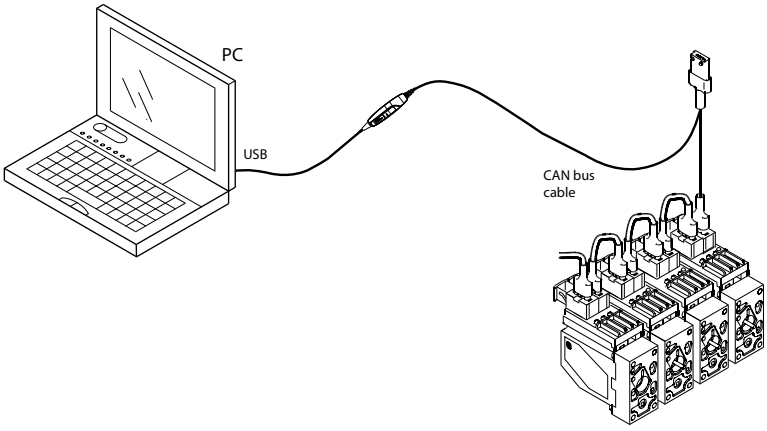
Error description

Errors overview (continued)

Index	CAN Value	SPN / FMI	Designation	Fault Status
15	0xD6 0x8F 0x80	SPN=298966 / FMI=0	Reserved for future use	Reserved
16	0x76 0x02 0x0C	SPN=630 / FMI=12	Calibration Memory	Permanent
17	0xF3 0x8F 0x8B	SPN=298995 / FMI=11	EEPROM: Fall Back to old values due to CRC16 failure	Warning
18	0x74 0x02 0x0C	SPN=628 / FMI=12	Program Memory	Permanent
19	-	-	"Main spool cannot reach neutral from retract".	Permanent
20	0xF2 0x8F 0x8C	SPN=298994 / FMI=12	SENSOR: LVDT wiring	Temporary
21	0x73 0x02 0x03	SPN=627 / FMI=3	Power Supply (exceeds specification)	Temporary
22	0x73 0x02 0x04	SPN=627 / FMI=4	Power Supply (below specification)	Permanent
23	0xF1 0x8F 0x8B	SPN=298993 / FMI=11	SUPERVISOR: No answer on handshakes	Permanent
24	0xF0 0x8F 0x8C	SPN=298992 / FMI=12	SUPERVISOR: power on self test failed	Permanent
25	0xD4 0x8F 0x82	SPN=298964 / FMI=2	VALIDATION: Timer values for CL-control out of range	Temporary / Permanent
26	0xEF 0x8F 0x87	SPN=298991 / FMI=7	CONTROL: Main spool can not reach neutral WebGPI: "Main spool cannot reach neutral from extend".	Temporary / Permanent
27	0xEE 0x8F 0x87	SPN=298990 / FMI=7	CONTROL: Float state not reached	Temporary / Permanent
28	0xED 0x8F 0x87	SPN=298989 / FMI=7	CONTROL: Main spool not in neutral at boot up	Temporary / Permanent
29	0xEC 0x8F 0x87	SPN=298988 / FMI=7	CONTROL: Main spool position is greater than the reference	Temporary / Permanent
30	0xEB 0x8F 0x87	SPN=298987 / FMI=7	CONTROL: Main spool position and the reference is in opposite direction	Temporary / Permanent
31	0xEA 0x8F 0x87	SPN=298986 / FMI=7	CONTROL: Float threshold has not been passed	Temporary
32	0xE9 0x8F 0x93	SPN=298985 / FMI=19	COMMUNICATION: Time guarding on Auxiliary Valve Command	Temporary
33	0xE8 0x8F 0x82	SPN=298984 / FMI=2	VALIDATION: Illegal CAN address	Warning
34	0xE7 0x8F 0x82	SPN=298983 / FMI=2	VALIDATION: Command out of range	Warning
35	0xE6 0x8F 0x82	SPN=298982 / FMI=2	VALIDATION: Scaling	Warning
36	0xE5 0x8F 0x82	SPN=298981 / FMI=2	VALIDATION: Ramps	Warning
37	0xE4, 0x8F, 0x82	SPN=298980 / FMI=2	VALIDATION: Float threshold	Warning
38	0xE3, 0x8F, 0x82	SPN=298979 / FMI=2	VALIDATION: Dead Band Compensation	Warning
39	0xE2, 0x8F, 0x82	SPN=298978 / FMI=2	VALIDATION: Slope	Warning
40	0xE1, 0x8F, 0x82	SPN=298977 / FMI=2	VALIDATION: Shape	Warning
41	0xE0, 0x8F, 0x82	SPN=298976 / FMI=2	VALIDATION: Invert port	Warning
42	0xDF, 0x8F, 0x82	SPN=298975 / FMI=2	VALIDATION: Illegal combination of Port Flow Command and Blocked.	Warning
43	0xDE, 0x8F, 0x82	SPN=298974 / FMI=2	VALIDATION: Illegal combination of Port Flow Command and Float state	Warning
44	0xDD, 0x8F, 0x82	SPN=298973 / FMI=2	VALIDATION: Port Flow Command above 100 %	Warning
45	0xDC, 0x8F, 0x82	SPN=298972 / FMI=2	VALIDATION: Illegal Valve State	Temporary
46	0xDB, 0x8F, 0x82	SPN=298971 / FMI=2	VALIDATION: Illegal Valve State and illegal Port Flow Command	Temporary
47	0xDA, 0x8F, 0x82	SPN=298970 / FMI=2	VALIDATION: Illegal combination of inverted ports and float properties	Temporary

Service tool

For parameter setting and reading by application engineering and service Danfoss has developed a service tool.



Requirements

- Service tool software PLUS+1® PVE Service Tool S4 DJ
- PC
- Service cable and CAN termination for PVED
- CG 150 CAN USB interface for PLUS+1®
- Power supply

Danfoss offers the PLUS+1® PVE Service tool S4 DJ (Series 4 Digital J1939) software for PVED-CC for free download. It can be downloaded from *http://www.danfoss.com*

11103046 Service tool S4 DJ self-extracting PC application

To install the PVED-CC PLUS+1® S4 DJ Service Tool run the executable fill.

Installation of the software is self instructing and choices should just be default accepted.

PLUS+1® PVE Service Tool S4 DJ

Caution

This software application:

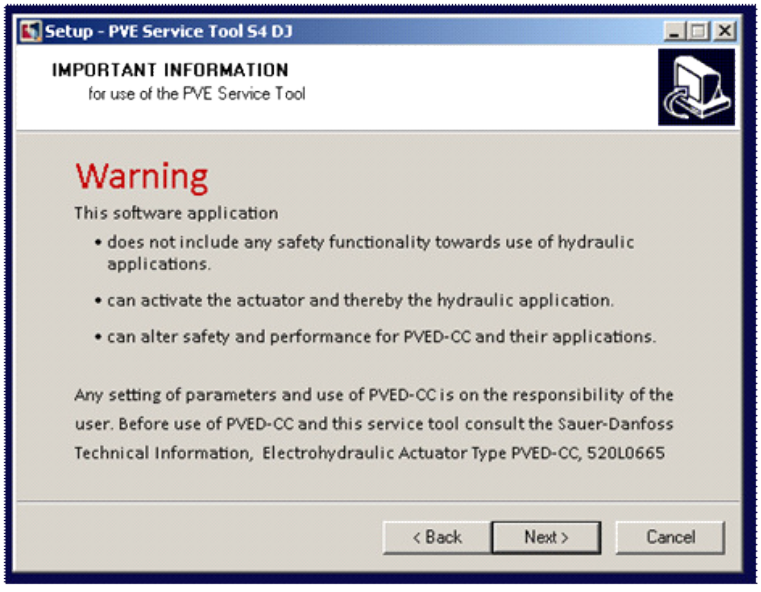
- does not include any safety functionality towards use of hydraulic applications,
- can activate the actuator and thereby the hydraulic application,
- can alter safety and performance for PVED-CC and their applications.

Any setting of parameters and use of PVED-CC is on the responsibility of the user.

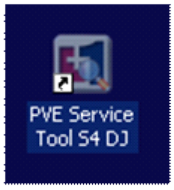
Installation

Before use of PVED-CC and this service tool consult the Danfoss Technical Information, PVED-CC, Series 4, Electrohydraulic Actuator, **520L0665**.

Service tool

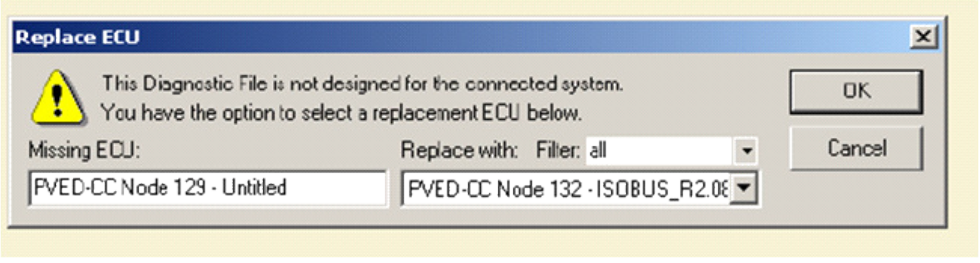


The PLUS+1® PVE Service Tool S4 DJ with included license runs as two installations.



Before initial start of the S4 DJ a PVED-CC must be connected to the PC via a CG150 and powered.

The application will only run if a PVED-CC is chosen



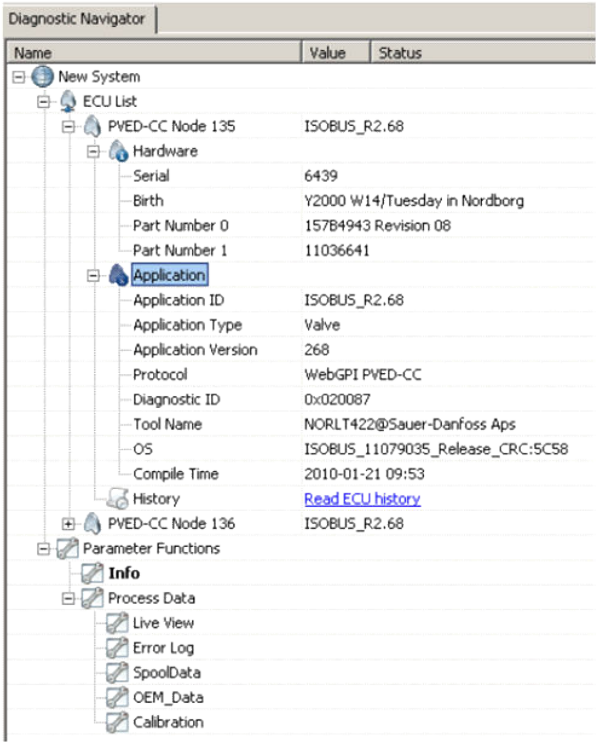
Use of service tool

The service tool includes a help tool.



If questions are not answered by this walk through please look up in the help tool. Parameters are supported by hover over descriptions. As a PLUS+1® standard the navigation pane to the left identifies all components on the bus.

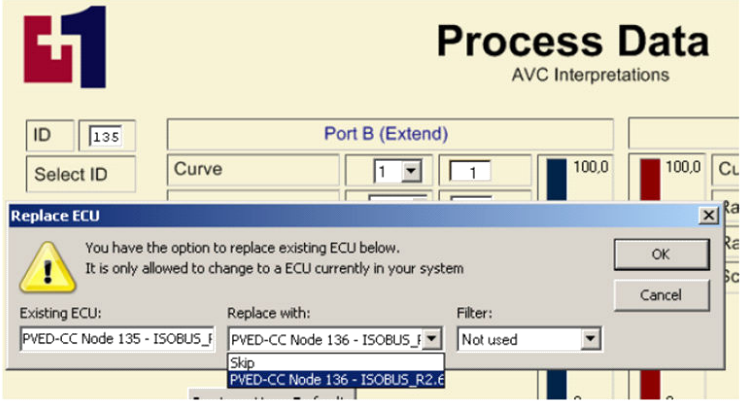
Service tool



Choosing PVED-CC (ECU)

When Process Data or one of the sub levels is chosen the PVED for examination can be selected/replaced.

- Push Select ID (default 128)
- open the Replace with curtain
- choose Node
- press OK



All parameters are represented by a setting field and a showing field.

The showing field tell what the last uploaded parameters from the PVED-CC was. This could have changed by a download (Download parameters to ECU (F4)) not followed by an upload (Upload parameters from ECU (F2))

Parameters can be changed choosing a value or just writing in the field. Parameters will only be available in the PVED-CC if a Download parameters to ECU (F4) is performed.

Service tool

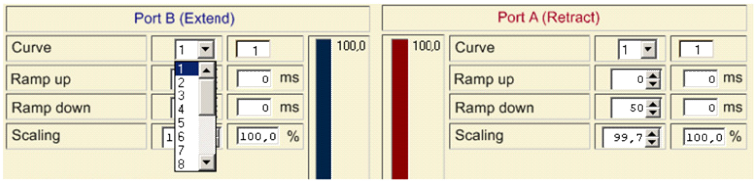
Parameters can be set by reading values from a file by using the “Load file to service tool” button. The PLUS+1® Service Tool will not allow parameter download by default if source and target do not have the same ID. To compensate the S4 DJ has a button for aligning source file to new targets.

Before download press **Align file to PVED** and then choose file to fit and ID of target. The XML is changed to new source/target number.

After aligning load file to service tool. When file is loaded to service tool, use F4 or button to load to PVED.

Caution

When changing Node ID in OEM Data, the PVED-CC must be rebooted.



Service tool will change selected value to best fit by step and range violation. See section Data description or section Parameter description or section Ordering.

Data in the protected field shows actual value in PVED. To change value in the PVED use the Download parameters to ECU button, Down arrow. It is recommended to use the upload button before saving data to file.



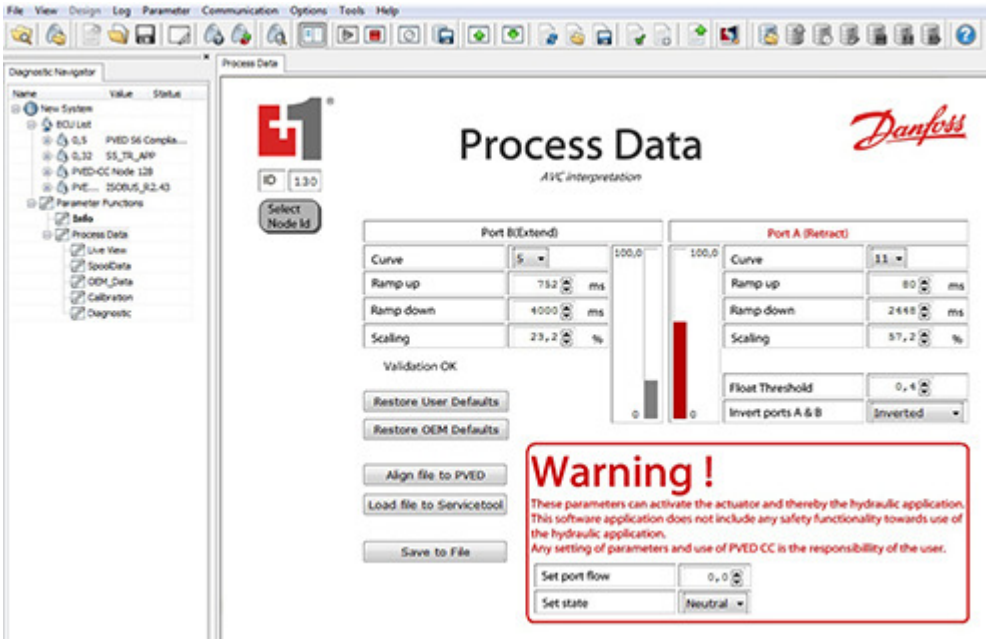
Process data screen

The Process Data screen gives access to the actual performance settings and an AVC tool.

Warning

Parameters in the AVC tool can activate the actuator and thereby the hydraulic application. This software application does not include any safety functionality towards use of hydraulic applications.
Any setting of parameters and use of PVED-CC is the responsibility of the user.

Service tool



Parameters can be changed manually. To eliminate any temporary errors always start by sending a blocked set point to the PVED before commanding any spool movement.

Restore User Defaults. Save user defaults overwrite present settings made by green arrow.

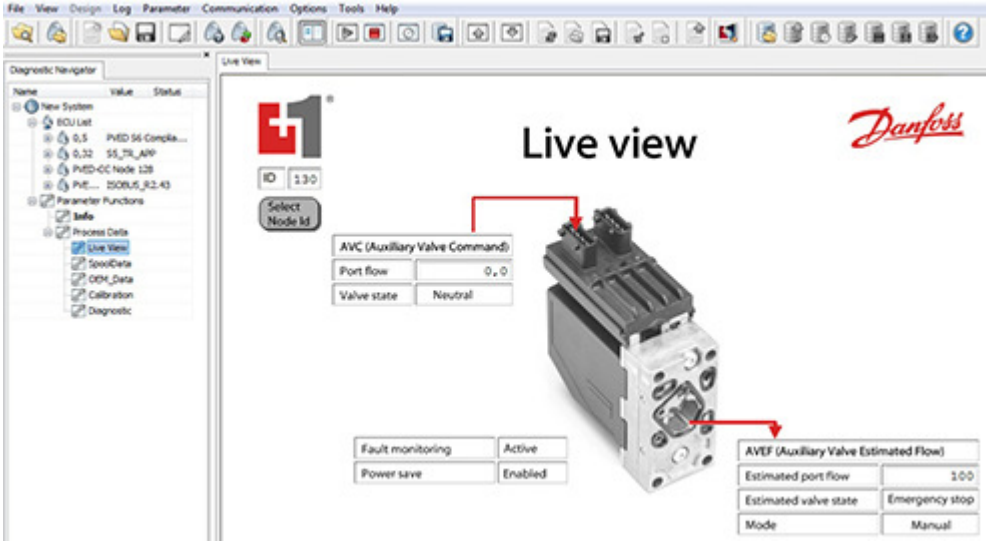
Restore OEM defaults. Values from OEM Settings are transferred to replace present Process Data.

Download parameters. Present setting in PVED is stored as user default. To make changes in the AVC tool active, a download of parameters to ECU (F4) must be performed.

Read from file. A file in xml-format with Process Data can be written to the tool.

Save to file. Present screen settings are stored to a file in xml-format.

Live view screen



The live view screen shows present AVC and AVEF.

Service tool

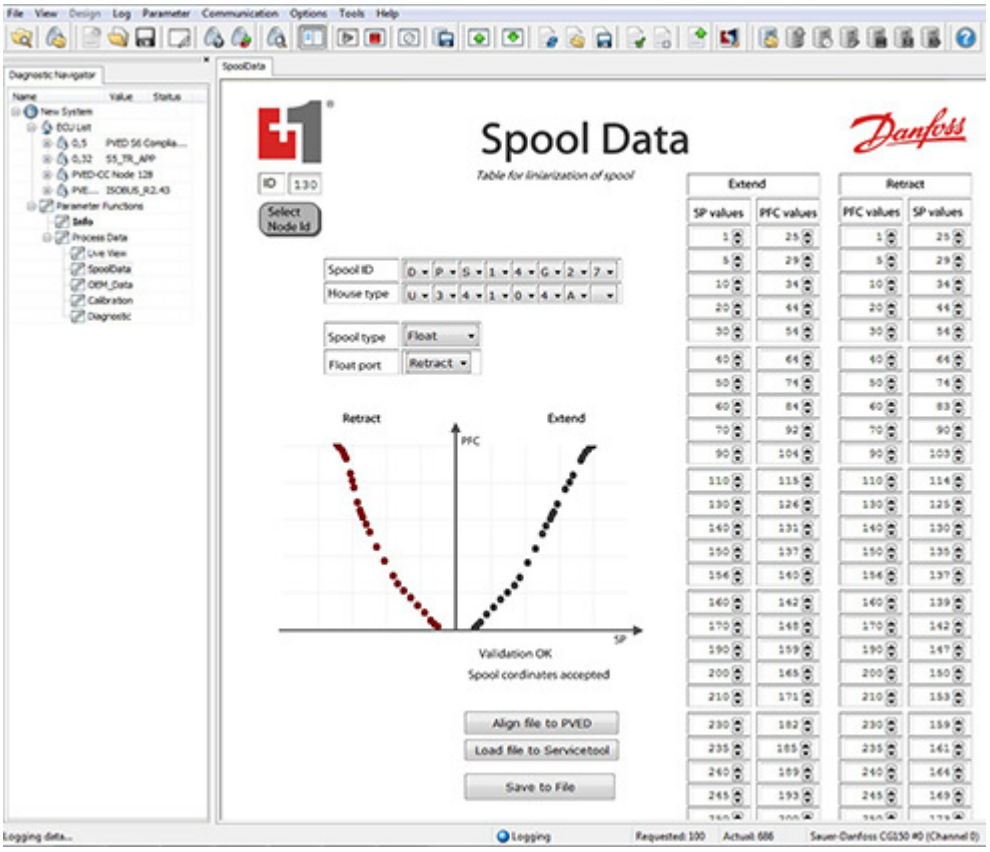
Error Log screen



The Error Log screen shows error history for PVED. Error Active indicates a DM1 is sent at the moment. Error no longer active shows that a DM1 has been but are no longer active. Save to file will save PVED parameters from ECU list and error history to a file in dBase format. Clear Error Log will send a DM3 to the PVED clearing all Error no longer active faults and add one to position 7 “Error log Cleared”.

Service tool

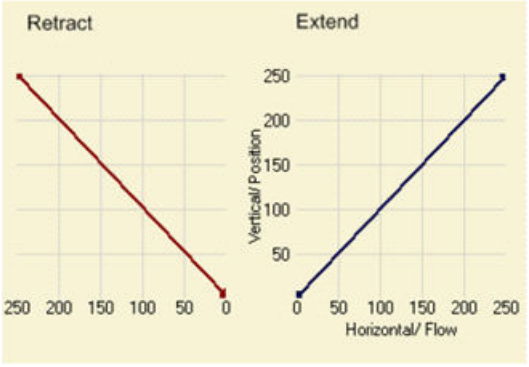
Spool Data screen



Retract is on the left in the graph and on the right in the table

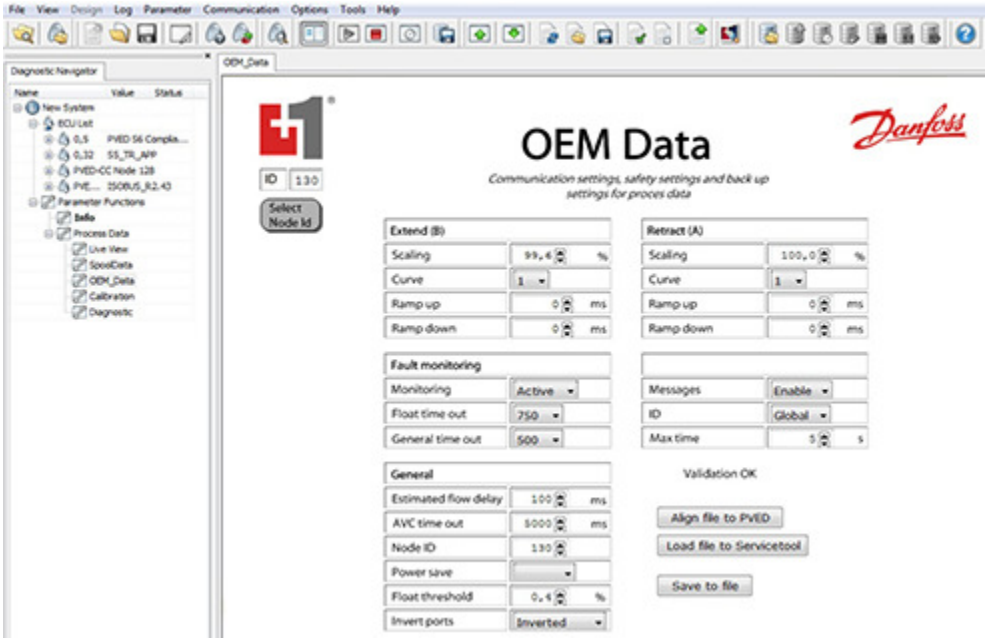
Spool Data Screen shows the spool linearization file. Parameters can be changed manually or by file download as for process data.

A spool curve with this characteristic will neither linearize nor have dead band compensation but will follow the spool mechanical characteristic with 250 positions each direction.



Service tool

OEM Data screen

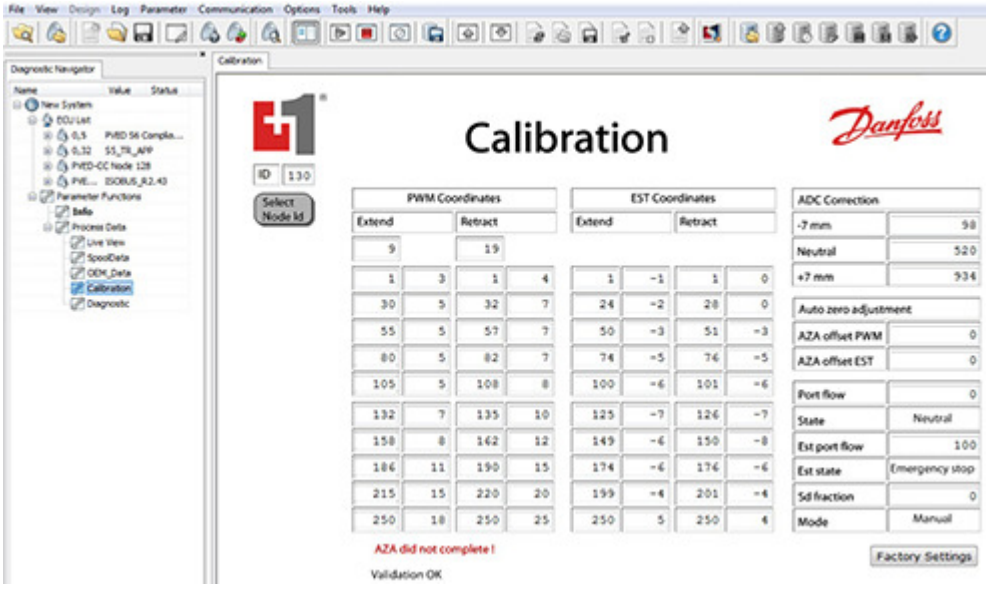


OEM DATA screen shows the present OEM data for the PVED. Parameters can be changed manually or by file download as for process data.

Warning

When changing Node ID the PVED-CC must be rebooted, bus scanned and the node ID re-selected.

Calibration screen



Calibration screen shows calibration parameters for the present PVED

Service tool

Use case

In all use cases PVED-CC must be connected to the service tool and powered. Additional ECU can be connected. Only one instance of every function instance (Node ID) can be present on the bus.

Creation of master file

Valid for Process Data, OEM Data and Spool Data

- Ensure screen shows right settings.
- Save to file.

PVED resetting to new parameter files

This process is relevant for end of line programming and service replacement. Valid for Process Data, OEM Data and Spool Data

- Open relevant screen
- Press Read from file
- Select master file and press ok
- Press “download parameters to ECU” arrow (F4)

If Node ID was changed this will only have effect after reboot.

If default Process Data is a copy of OEM Data only a press Restore OEM Defaults on Process Data screen is required.

Ordering

When PVG 32 with PVED-CC are ordered a Settings Agreement must be forwarded as well as assembly specification.

Agreements can be made as a

- Specific agreement for a single specification
- General agreement for PVG

Parameter agreement template

Customer OEM Parameter list - OEM Data for PVED-CC

Agreement between

Customer Name:

Business unit PVG, Danfoss:

Filled in by:

Customer representative:

Danfoss sales representative:

Date:

Factory settings for spare part PVED-CC

Name, description	Value Range	Default Value
OEM Scaling Extend	0-250 (0-100% , step 0.4%)	250
OEM Scaling Retract	0-250 (0-100% , step 0.4%)	250
Slope Extend (lineary to progressive)	0 7 13 18 25 31 37 44 49 56 61 68 77 81 88 94	0 (linearly)
OEM Slope Retract (lineary to progressive)	0 7 13 18 25 31 37 44 49 56 61 68 77 81 88 94	0 (linearly)
OEM Ramp Extend Up (0 to 4 sec)	0-250 (0-4000ms in step of 16ms)	0
OEM Ramp Extend Down (0 to 4 sec)	0-250 (0-4000ms in step of 16ms)	0
OEM Ramp Retract Up (0 to 4 sec)	0-250 (0-4000ms in step of 16ms)	0
OEM Ramp Retract Down (0 to 4 sec)	0-250 (0-4000ms in step of 16ms)	0
OEM Float Threshold (port flow command must be above this value to allow float)	0-250 (0-100% , step 0.4%)	1 (0.4%)
OEM Invert port	0 non-inverted , 1 inverted	0 (non-inverted)
OEM Estimate Sendout Time (how often is Estimate Flow send on CAN bus)	0 - 64255 ms, 65535 is disable (step of 10 ms)	100 ms
OEM Aux. Valve Command Timeout	0 - 65535, 0 is disabled (step of 10 ms)	0 ms
OEM Node ID	128-143 (0x80- 0x8F)	128
OEM Power Save Enable	0 FALSE, 255 TRUE	255 TRUE
OEM Validation	0 FALSE, 255 TRUE	255 TRUE
Supervision of closed loop control is Active	0 FALSE (Temporary), 255 TRUE (Permanent)	255 TRUE
Supervision of closed loop control Float Timeout	750, 1000, 1250, 1500, 1750 ms	750 ms
Supervision of closed loop control General Timeout	250, 500, 750, 1000, 1250, 1500, 1750, 2000 ms	500 ms
KWP2000 Max time between Messages in Sec	0 – 255	5
KWP2000 Enable	0 FALSE, 255 TRUE	255 TRUE
KWP2000 Use Specific ID	0 FALSE, 255 TRUE	0 FALSE

Ordering

PVED-CC setting agreement for PVG

	Value Range	PVED1	PVED2	PVED3	PVEDN
ScalingExtend	0-250 (0-100% , step 0.4%)	250	250	250	250
ScalingRetract	0-250 (0-100% , step 0.4%)	250	250	250	250
ExtendCurve	0 7 13 18 25 31 37 44 49 56 61 68 77 81 88 94	0 (linearly)	0 (linearly)	0 (linearly)	0 (linearly)
RetractCurve	0 7 13 18 25 31 37 44 49 56 61 68 77 81 88 94	0 (linearly)	0 (linearly)	0 (linearly)	0 (linearly)
RampExtendU	0-250 (0-4000ms, step 16ms)	0	0	0	0
RampExtendD	0-250 (0-4000ms, step 16ms)	0	0	0	0
RampRetractU	0-250 (0-4000ms, step 16ms)	0	0	0	0
RampRetractD	0-250 (0-4000ms, step 16ms)	0	0	0	0
FloatThreshold	0-250 (0-100% , step 0.4%)	1 (0.4%)	1 (0.4%)	1 (0.4%)	1 (0.4%)
Invport	0 non-inverted , 1 inverted	0 (non-inverted)	0 (non-inverted)	0 (non-inverted)	0 (non-inverted)
SendoutTimeLSB SendoutTimeMSB	0 - 64255 ms, 65535 is disable (step of 10 ms)	100 ms	100 ms	100 ms	100 ms
AVCTimeoutLSB AVCTimeoutMSB	0 - 65535, 0 is disabled (step of 10 ms)	0	0	0	0
NodeID	128-143 (0x80- 0x8F)	129	130	131	134
PowerSaveEnable	0 FALSE, 255 TRUE	255 TRUE	255 TRUE	255 TRUE	255 TRUE
Validation	0 FALSE, 255 TRUE	255 TRUE	255 TRUE	255 TRUE	255 TRUE
SupervisCLCActive	0 FALSE (Temporary), 255 TRUE (Permanent)	255 TRUE	255 TRUE	255 TRUE	255 TRUE
SupervisFloatTOLSB SupervisFloatTOLSB	0 - 65535 ms, (step of 10 ms)	750 ms	750 ms	750 ms	750 ms
SupvisGenTOLSB SupvisGenTOLSB	0 – 65535 ms, (step of 10 ms)	500 ms	500 ms	500 ms	500 ms
KWP2000MsgTime	0 – 255	5	5	5	5
EnableKWP2000	0 FALSE, 255 TRUE	255 TRUE	255 TRUE	255 TRUE	255 TRUE
UsedSpecificID	0 FALSE, 255 TRUE	0 FALSE	0 FALSE	0 FALSE	0 FALSE

PVED 1 is the PVED closest to PVP.

All changed cell must have light gray shading and bold font.

Code numbers

PVED-CC code numbers

Connector code numbers

Connector		Part number
DEUTSCH	PVG 32 & 100	11079033
	PVG 120	11111113
AMP	PVG 32 & 100	11079034
	PVG 120	11111117

Connector kit code number

Name	Part number
AMP CONNECTING KIT (GREY) 4 pin with housing, contact and wire sealing	157B4992

Connector part numbers for purchase at other suppliers

Connector			House	wire sealing (blue)	JPT contact (loose piece)	sealing mat between male-female part
Deutsch® female		4 pin	DT06-4S			
		6 pin	DT06-6S			
AMP female	gray	4 pin	2-967059-1	828904-1	929930-1	963208-1
		6 pin	2-963212-1			963205-1
AMP female	black	4 pin	1-967059-1			
AMP crim tool			169400-1			
AMP die set for crimp tool			734253-0			

CAN Interface code numbers

Name	Part number
CG 150 CAN USB interface	10104136
WebGPI gateway	162B0004

Set of seals code numbers

Actuator	Part number
Seal Kit PVE 32	157B4997
Seal kit PVE 120	155G8519

CAN cables:

- Mineral oil resistant conductor insulation and outer insulation
- V_{DC} (red) and ground (black): 2 x 1.5 mm^2
- CAN-H (green) and CAN-L (yellow): 2 x 0.5 mm^2, twisted pair

Code numbers

Cables code numbers

Cable Connector Seal	Cable description	Wire colors				Code number
		pin 1	pin 2	pin 3	pin 4	
DEUTSCH	4 m connection	Green	Yellow	Black	Red	11095741
	100 mm loop					11007531
	175 mm loop (32/100)					11095622
	350 mm loop (32/120)					11111916
	Termination, 120 ohm					11007561
	Termination, dummy					11007563
AMP	4 m connection, gray coding	Yellow	Red	Black	Green	11095740
	100 mm loop					157B4987
	175 mm loop (32/100)					11095581
	Termination, 120 ohm , black coding					157B4988
	Termination, 120 ohm , gray coding					11163647

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