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Technical Information

Steering

PVED-CL Communication Protocol, version 1.38

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Revision history

Table of revisions

Date	Changed	Rev
July 2014	Danfoss layout.	BA
07 September, 2010	New standard backpage.	AD
10 February, 2010	Two new positions 11176,77 in the table - minor change.	AC
08 February, 2010	Position 11152 in the table - minor change.	AB
28 January, 2010	First edition. For PVED-CL software release version 1.38	AA

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Introduction

Purpose of the document

This document has been created in order to present the communication protocol implemented in PVED-CL – a controller in the Electro-hydraulic Power Steering system. The document describes the CAN messages which enables the PVED-CL and relevant sensor to be connected to a J1939 network.

Conventions

- As suggested in J1939 protocol documentation, the little-endian layout applies to all multi-byte numerical values, any exception requires an explicit note.
- Unless otherwise mentioned, all signed numerical values are encoded in two's complement format. The CAN Data field byte numbers start from 1.

Reference documents

Refering to literature:

Reference	Title/author
[PVED]	Controller for Electro-Hydraulic Steering PVED, User Manual, **11079550**.
[J1939]	SAE J1939 Top Level
[J1939-21]	SAE J1939 Data Link Layer
[J1939-71]	SAE J1939 Application Layer
[J1939-73]	SAE J1939 Diagnostic Layer
[J1939-81]	SAE J1939 Network Management

Definitions and abbreviations

Definitions and abbreviations

Term	Description
DTC	Diagnostic Trouble Code
EHPS	Electro-Hydraulic Power Steering
MMI	Man-Machine Interface
XID	Extended Message Identifier
PVED-CL	Proportional Valve Digital – Closed Loop – here the valve controller
SPN	Suspect Parameter Number

Communications

J1939/ISOBUS compliance

Network Management Protocol (NMP)

To make PVED-CL able to work in CAN J1939 networks, the following parts of NMP have been implemented:

- Address Claimed
- Request for Address Claimed response

PVED-CL claims it address on power-on, after any won address arbitration and when requested to do so. However, please note that because of some platform and software architecture constraints, PVED-CL may claim its address even when it's not needed. This is triggered by a **RequestParameterGroup** message – no matter which node has sent it and which one the message is addressed to – as illustrated on figure below.

Identification

There are 2 items which identify PVED-CL:

- Source Address – available in all 29bit ID messages sent by PVED-CL
- NAME – broadcast while claiming the address

Apart from this, the protocol supports the following proprietary identification:

- PVED Serial Number available as a read-only parameter at index 65001
- Sales Order Number at index 65002
- Software Version Number at index 65003
- Parameter Definition File at index 65004

SoftwareID (pgn65242) and ComponentID (pgn65259) defined by [J1939-71] are not available.

Application layer

Some steering functionality requires the **Wheel Based Vehicle Speed signal** (spn84) available in pgn65265 – for more detailed information see *Vehicle speed* on page 15. The standardized guidance messages are available in pgn44288 (Guidance System Command) and pgn44032 (Guidance Machine Status). Further details see *GuidanceSystemCommand* on page 33.

PVED-CL supports Request PG message, but recognizes only requests for Address Claimed (pgn60928), DM1 (pgn65226), DM2 (pgn65227) and DM3 (pgn65228). All other requests, if addressed explicitly to PVED-CL, are answered with NACK (pgn59392).

Please note the following limitations:

- Only 4 ACK/NACK messages can be buffered for transmission. Other requests will be ignored
- If Request PG messages are sent too fast (with an interval less than 20 ms), some messages may be lost.

Diagnostics

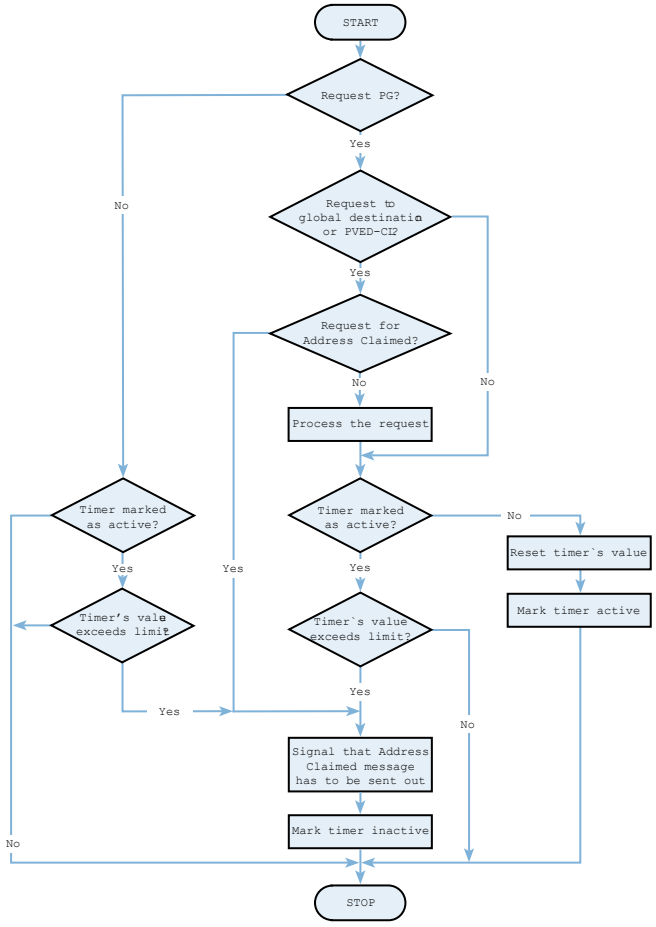
PVED-CL supports the following items defined by the J1939 diagnostic protocol [J1939-73]:

- DM1 – Active Diagnostic Trouble Codes
- DM2 – Previously Active Diagnostic Trouble Codes
- DM3 – Diagnostic Data Clear/Reset for Previously Active DTCs

A request for DM3 results in resetting the Occurrence Counts for Previously Active DTCs.

Communications

Reception of request parameter group message



Due to software architectural limitations, the following deviations apply:

- If DM1 message (expected to be sent every 1s) is a long message and a long upon-the-request DM1/DM2 is being sent out, the transmission of the cyclic message will be skipped
- If DM2 is a long message – more than one CAN message is needed – it will always be transmitted to the global destination (preceded with the Broadcast Announce Message)

Proprietary error codes are available for deep diagnostics. Further details can be found in *Diagnostics (proprietary)* on page 35.

Proprietary messages

Both proprietary A and B messages are in use. PDU1 proprietary messages (pgn61184) are used for configuration and control commands as well as **GetCurrentMode** and **GetCurrentModeResponse** messages, whereas PDU2 format is used for broadcast status messages.

PVED-CL uses a separate CAN buffer for receiving data from each node it can communicate with. This means there's no dependency between messages with pgn61184 sent from different nodes.

As three different status messages can be broadcast, three proprietary PDU2 parameter group numbers are needed.

These numbers are as follows:

- (65280 + offset_base)
- (65280 + offset_base + 1)
- (65280 + offset_base + 2)

Communications

where the offset_base is any value within the range [0…253] and can be selected with the configuration tool. It's OEM's responsibility to make sure that offset_base is not programmed to a value that results in pgns other nodes may use for different purposes.

Due to a relatively high number of exchanged messages, it's recommended to implement a separate CAN bus for the EHPS system only.

11bit ID messages

Most of the communication between PVED-CL and sensors/steering devices is performed with 11bit ID messages. This makes the sensors simpler and allows them to be used in networks with other protocols.

Communications

Proprietary protocol

General

Because J1939 documents do not define a standard communication protocol for systems like EHPS, a proprietary one has been defined on top of the existing common mechanisms described in previous section. The proprietary protocol covers issues related to the communication with sensors, configuration, status information, etc. Detailed information is available in the following sections.

The following general rules apply:

- the time delay between messages marked as "**when needed**" shall not be less than 100 ms
- PVED-CL shall respond within 200 ms, with exception for **CommitDataResponse** – 5000 ms
- a response timeout shall be 500 ms (does not apply to **CommitDataResponse** message)
- a not allowed command is ignored what results in no response sent back. Timeout policy shall apply
- as a proprietary protocol is in use, default message priority shall be set to 6

PVED-CL's can receive messages from selected nodes only. The source addresses of the vehicle speed sensor, the MMI controller, the high priority external set-point controller as well as the configuration tool and PVED-CL itself are configurable.

The default factory programmed values

Node	Default Source Address
PVED-CL	19
High priority external set-point controller	28
Vehicle speed sensor	251
MMI controller	252
Configuration/diagnostic tool	253

Communication with sensors and steering devices

In general, most of this type communication is performed with 11bit ID messages. More details about message formats can be found in chapter *Communication with sensors and steering devices* on page 9.

A sensor is expected to periodically broadcast the data. A lack of data from the mapped sensor (with exception for high priority set-point controller) causes PVED-CL to fail silent or enter the reduced mode, depending on the configuration data. The timeouts are as follows:

The timeouts

Sensor or Steering Device:	Timeout [ms]
Steering wheel sensor	100
High priority steering device	100
Low priority steering device	100
Primary steered wheel angle/position sensor	60
Redundant steered wheel angle/position sensor	60
Vehicle speed sensor	160

Configuration

PVED-CL's configuration memory contain parameters which identify the system components and control the device's behaviour. These parameters can be set up with a configuration tool.

The following operations are available:

Communications

- retrieving a parameter value
- setting a parameter value
- committing data to non-volatile memory
- entering the calibration mode
- restoring factory defaults

Secondary configuration device

Beside the configuration tool, the high priority external set-point controller has an access to the parameter data, too. However, this device's rights are limited to only reading the configuration settings.

Status

The information about control and sensor variables as well as PVED-CL's current time and mode can be found in periodically broadcast status messages. For further details see chapter *Status* on page 22.

Control

Control messages have been implemented to make the operator able to enable/disable steering devices dynamically. This is especially useful when e.g. a joystick is mounted on the armrest and can be unintentionally activated while getting on/off the machine. Disabling a steering device prevents the controller from using the device set-points for steering. Default power-on state can be configured with proper parameters stored in non-volatile memory.

The figure below shows the steering device disabling/enabling procedure. State transitions are receptions of disable steering device commands and/or message timeouts which are set to 200 ms. For further details see *Control* on page 27.

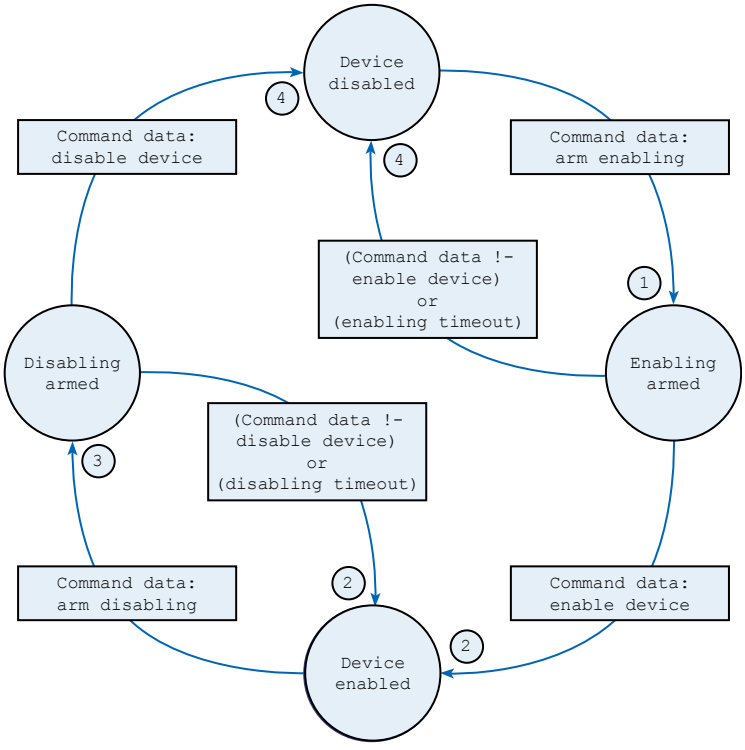
The numbers in octagons show where a response is sent back (**DisableSteeringDeviceResponse** message):

1. Response data: enabling armed
2. Response data: device enabled
3. Response data: device disabling armed
4. Response data: device disabled

The current state of the device will be reported back if a command does not follow what's on the figure. Note that there are independent state machines implemented for each steering device which can be disabled.

Communications

Device enable/disable state transitions

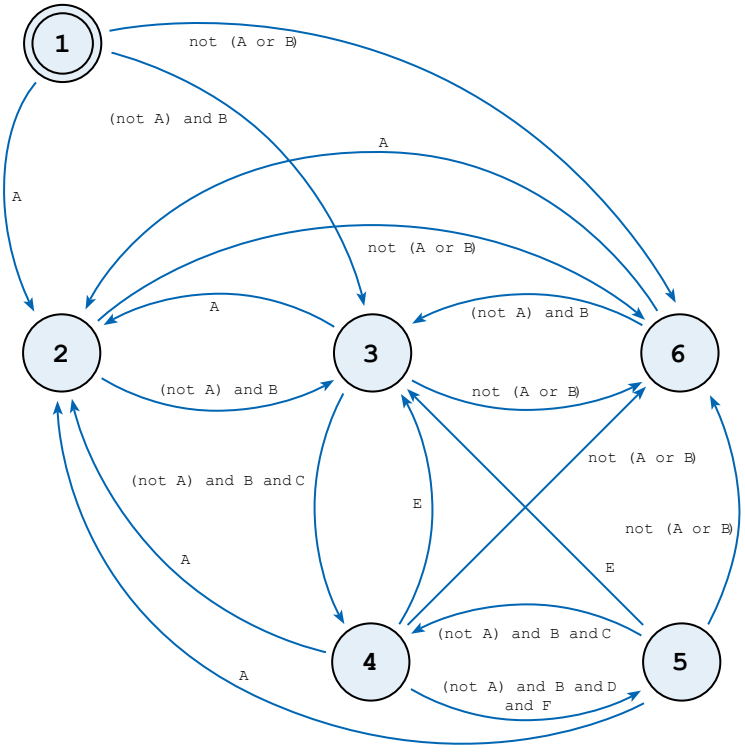


Guidance

The high priority external set-point controller does not communicate with the PVED-CL the same way as other steering devices do. The set-point controller is expected to provide PVED-CL with ISOBUS curvature commands. This approach needs a special group of messages described in *Guidance* on page 33 and the state machine shown on the figure *Guidance Engage and Disengage State Machine* below. Please note that the state machine is executed only when PVED-CL is in the operational mode, or reduced mode and the high priority external set-point controller is mapped.

Communications

Guidance engage and disengage state machine



Please note that no active transaction means no state change happens.

State definitions

1	Initialization
2	High priority set-point controller disabled (device disable functionality available in PVED-CL). If other steering device is selected, PVED-CL follows set-points from this device
3	PVED-CL requests the high priority set-point controller for a message reset. It waits for at least one GuidanceSystemCommand message not intended for steering
4	PVED-CL waits for curvature requests intended for steering
5	PVED-CL follows curvature requests
6	PVED-CL follows set-points from other steering device

Conditions

A	High priority set-point controller disabled (device disable functionality available in PVED-CL)
B	No other steering device selected or set-points (from other steering device) below threshold
C	New curvature request received, but not intended for steering
D	New curvature request received, intended for steering
E	Timeout – no new curvature request has been received for 200 ms
F	Steering wheel disengage ability check has been passed or is disabled

Communications

Flags available in status messages (guidance machine status)

State	Request Reset Command Status	Steering Input Position Status	Machine can Execute Commands	Mechanical System Lockout
1	No status message transmitted			
2	00 – reset not required	**11 – not available**	**11 – not available**	**01 – active**
3	**01 – reset required**	01 – correct position or 10 – error indication[1)]	00 – system is not ready	00 – inactive
4	00 – reset not required	01 – correct position or 10 – error indication[1)]	00 – system is not ready	00 – inactive
5	00 – reset not required	01 – correct position	**01 – system is ready**	00 – inactive
6	00 – reset not required	**00 – incorrect position**	00 – system is not ready	00 – inactive

[1)] Error indication is reported if the steering wheel disengage ability check (if enabled) has failed. This means that too much time has passed since a steering wheel position change has last exceeded the defined position change threshold. Both the position change threshold and the timeout value can be configured as required by the application.

To allow removable set-point controllers to be used, vehicle specific data can be stored in the PVED-CL's configuration memory. For further details refer to *PVED-CL User Manual*, **11079550**.

Diagnostics

Although PVED-CL supports J1939 diagnostic protocol [J1939-73], there exists a proprietary way of informing about errors. The configuration/diagnostic tool has an access to the event logs maintained by PVED-CL's software, which is intended to make the debugging easier as well as to help an OEM or a support team to tune the system. Detailed information about the interface is provided in the chapter *Diagnostics (proprietary)* on page 35.

Communication with sensors and steering devices

Steering wheel absolute angle and speed

The message data represents the absolute position of the steering wheel and the position change.

CAN message

CAN id.	0x301 (11bit)
Occurrence	every 5, 10 (recommended) or 20 ms
Sent by	steering wheel angle sensor

Data field

Bytes	Encoding	Value/Range	Description
1, 2	UNSIGNED16	0 – 4095	position – reflects 0 – 359.9121 deg. with the resolution of 0.0879 deg. Rolls over after a full turn
3	–	–	ignored by PVED-CL
4, 5	SIGNED16	-4095 – 4095	position change – reflects -359.9121 – 359.9121 deg. with the resolution of 0.0879 deg
6-8	–	–	ignored by PVED-CL

High priority steering device position

The message data represents the position of the high priority steering device.

CAN message

CAN id.	0x304 (11bit)
Occurrence	every 80 ms or less (recommended 10 ms)
Sent by	high priority steering device

Data field

Bytes	Encoding	Value/Range	Description
1, 2	UNSIGNED16	0 – 4095 0 2047 4095	Position: – left end lock – neutral position – right end lock

Low priority steering device position

The message data represents the position of the low priority steering device.

CAN message

CAN id.	0x406 (11bit)
Occurrence	every 80 ms or less (recommended 10 ms)
Sent by	low priority steering device

Communication with sensors and steering devices

Data field

Bytes	Encoding	Value/Range	Description
1, 2	UNSIGNED16	0 – 4095 0 2047 4095	Position: – left end lock – neutral position – right end lock

Primary steered wheel angle/position

The message data represents either the position of the steering actuator or the steered wheel angle

CAN message

CAN id.	0x105 (11bit)
Occurrence	every 40 ms or less (recommended: 10 ms)
Sent by	primary steered wheel angle/position sensor

Data field

Bytes	Encoding	Value/Range	Description
1, 2	UNSIGNED16	0 – 4095	Position: 0 – left end lock 2047 – neutral position (vehicle's moving straight ahead) 4095 – right end lock

Redundant steered wheel angle/position

The message data represents either the position of the steering actuator or the steered wheel angle.

CAN message

CAN id.	0x205 (11bit)
Occurrence	every 40 ms or less (recommended: 10 ms)
Sent by	redundant steered wheel angle/position sensor

Data field

Bytes	Encoding	Value/Range	Description
1, 2	UNSIGNED16	0 – 4095 0 2047 4095	Position: – left end lock – neutral position (vehicle's moving straight ahead) – right end lock

High priority external set-point controller

The communication with the high priority external set-point controller is performed in a special way, with messages described in *Guidance* on page 11.

Vehicle speed

This is a standard message used for broadcasting the information about the vehicle speed [J1939 – 71].

Communication with sensors and steering devices

CAN message

Priority	6
PGN	65265
Occurrence	every 100 ms
Sent by	vehicle speed sensor

Data field

Bytes	Encoding	Value/Range	Description
1	–	–	ignored by PVED-CL
2, 3	UNSIGNED16	0 – 64255	vehicle speed in 1/256 km/h reflects 0 – 250.996 km/h
4 – 8	–	–	ignored by PVED-CL

Configuration

GetParameter

This message is used to retrieve a value of a given parameter. If an unknown parameter value is requested, no response will be sent back. Timeout policy shall be applied.

CAN message

Priority	6
PGN	61184
XID	0x0FA0 (MSB first)
Occurrence	when required
Modes	operational, reduced, calibration and fault
Sent by	configuration tool, high priority external set-point controller
Sent to	PVED-CL

Data field

Bytes	Encoding	Value/Range	Description
1, 2	UNSIGNED16	0x0FA0 (MSB first)	extended message identifier (XID)
3, 4	UNSIGNED16	(see parameter list)	parameter index

GetParameterResponse

This message is sent upon the **GetParameter** request and contains both parameter index and parameter value.

CAN message

Priority	6
PGN	61184
XID	0x0FA1 (MSB first)
Occurrence	upon request
Modes	operational, reduced, calibration and fault
Sent by	PVED-CL
Sent to	configuration tool or high priority external set-point controller

Data field

Bytes	Encoding	Value/Range	Description
1, 2	UNSIGNED16	0x0FA1 (MSB first)	extended message identifier (XID)
3, 4	UNSIGNED16	(see parameter list)	parameter index
5 – 8	UNSIGNED32	(depends on a parameter)	parameter value

SetParameter

This message is used to set value of a given parameter. Please note that the values are not stored in non-volatile memory unless **CommitData** command is sent.

Configuration

CAN message

Priority	6
PGN	61184
XID	0x0FA2 (MSB first)
Occurrence	when required
Modes	operational, reduced, calibration
Sent by	configuration tool
Sent to	PVED-CL

Data field

Bytes	Encoding	Value/Range	Description
1, 2	UNSIGNED16	0x0FA2 (MSB first)	extended message identifier (XID)
3, 4	UNSIGNED16	(see parameter list)	parameter index
5 – 8	UNSIGNED32	(depends on a parameter)	parameter value

SetParameterResponse

Sent back upon the **SetParameter** request and contains both parameter index and value. If, due to any reason, parameter value has not been changed, the previous and still valid one is reported.

CAN message

Priority	6
PGN	61184
XID	0x0FA3 (MSB first)
Occurrence	upon request
Modes	operational, reduced, calibration
Sent by	PVED-CL
Sent to	configuration tool

Data field

Bytes	Encoding	Value/Range	Description
1, 2	UNSIGNED16	0x0FA3 (MSB first)	extended message identifier (XID)
3, 4	UNSIGNED16	(see parameter list)	parameter index
5 – 8	UNSIGNED32	(depends on a parameter)	parameter value

RestoreDefaults

Used to set all parameter values to factory defaults.

Please note that the values are not stored in non-volatile memory unless **CommitData** command is sent.

CAN message

Priority	6

Configuration

CAN message (continued)

PGN	61184
XID	0x0FA4 (MSB first)
Occurrence	when required
Modes	operational, reduced, calibration
Sent by	configuration tool
Sent to	PVED-CL

Data field

Bytes	Encoding	Value/Range	Description
1, 2	UNSIGNED16	0x0FA4 (MSB first)	extended message identifier (XID)
3	UNSIGNED8	0x5C	check value

RestoreDefaultsResponse

Sent back to signal the status.

CAN message

Priority	6
PGN	61184
XID	0x0FA5 (MSB first)
Occurrence	upon request
Modes	operational, reduced, calibration
Sent by	PVED-CL
Sent to	configuration tool

Data field

Bytes	Encoding	Value/Range	Description
1, 2	UNSIGNED16	0x0FA5 (MSB first)	extended message identifier (XID)
3	UNSIGNED8	0x00 0x0FF	- restoring defaults failed - all parameter values changed to factory defaults

CommitData

This is a request for copying all modified parameters to non-volatile memory.

CAN message

Priority	6
PGN	61184
XID	0x0FA6 (MSB first)
Occurrence	when required
Modes	operational, reduced, calibration

Configuration

CAN message (continued)

Sent by	configuration tool
Sent to	PVED-CL

Data field

Bytes	Encoding	Value/Range	Description
1, 2	UNSIGNED16	0x0FA6 (MSB first)	extended message identifier (XID)
3	UNSIGNED8	0x5A	check value

CommitDataResponse

Sent back to signal any change in the commit process status.

This means the **CommitData** command may result in several responses, e.g. ready > in progress > succeeded.

The minimum delay between responses is set to 40 ms.

CAN message

Priority	6
PGN	61184
XID	0x0FA7 (MSB first)
Occurrence	upon request
Modes	operational, reduced, calibration
Sent by	PVED-CL
Sent to	configuration tool

Data field

Bytes	Encoding	Value/Range	Description
1, 2	UNSIGNED16	0x0FA7 (MSB first)	extended message identifier (XID)
3	UNSIGNED8	0x00 0x01 0x02 0x03 0x04 0x05	Commit status: – ready to perform commit operation – commit operation has just begun – the operation succeeded – the operation failed – parameter cross-check failed – commit is already in progress
4, 5	UNSIGNED16	Commit error code	If commit operation failed, an error code on the particular parameter cross-check is issued. If commit operation succeeded, the value is 0. Please refer to *Commit Error Code* on page 37.

EnterCalibrationMode

This command is used to force PVED-CL to enter the calibration mode, for further information see *PVED-CL User Manual*, **11079550** and shall be sent within 200ms after PVED-CL transmits its **Address Claimed** message.

Once the system state changes to Calibration, a response – **GetCurrentModeResponse** with a proper mode identifier – will be sent back.

Configuration

CAN message

Priority	6
PGN	61184
XID	0x0FA8 (MSB first)
Occurrence	if required, within 200ms after PVED-CL's Address Claim
Modes	only during start-up
Sent by	configuration tool
Sent to	PVED-CL

Data field

Bytes	Encoding	Value/Range	Description
1, 2	UNSIGNED16	0x0FA8 (MSB first)	extended message identifier (XID)
3	UNSIGNED8	0x58	check value

Status

GetCurrentMode

Used to get the information about the current PVED-CL mode.

CAN message

Priority	6
PGN	61184
XID	0x0FA9 (MSB first)
Occurrence	when required
Modes	operational, reduced, calibration, fault
Sent by	configuration tool
Sent to	PVED-CL

Data field

Bytes	Encoding	Value/Range	Description
1, 2	UNSIGNED16	0x0FA9 (MSB first)	extended message identifier (XID)

GetCurrentModeResponse

Information about the current mode.

CAN message

Priority	6
PGN	61184
XID	0x0FAA (MSB first)
Occurrence	200 ms after claiming an address (if no address arbitration lost) and upon request
Modes	operational, reduced, calibration, fault
Sent by	PVED-CL
Sent to	configuration tool

Data field

Bytes	Encoding	Value/Range	Description
1, 2	UNSIGNED16	0x0FAA (MSB first)	extended message identifier (XID)
3	UNSIGNED8	0x55 0x0AA 0x0AF 0x0FF	current mode: – calibration – operational – reduced – fault

StartStopStatus

This command is used to make PVED-CL start/stop sending status information. Power-on state: status disabled.

Status

CAN message

Priority	6
PGN	61184
XID	0x0FAB (MSB first)
Occurrence	when required
Modes	operational, reduced, calibration
Sent by	configuration tool
Sent to	PVED-CL

Data field

Bytes	Encoding	Value/Range	Description
1, 2	UNSIGNED16	0x0FAB (MSB first)	extended message identifier (XID)
3	UNSIGNED8	0x00 0x01 0x02 0x03 0x04	stop sending status information request for status data set no. 1 request for status data set no. 2 request for status data set no. 3 request for status data set no. 4

Status

Used to broadcast sensor or control variables on the CAN bus. In fault mode broadcasting is stopped to minimize the bus load and avoid incorrect hazardous actions done by devices that rely on the message.

CAN message

Priority	6
PGN	65280 + offset_base
XID	n/a
Occurrence	every 40 ms. Only if Status messages are enabled
Modes	operational, reduced,calibration
Sent by	PVED-CL
Sent to	all nodes

Set no. 1

Bytes	Encoding	Value/Range	Description
1, 2	SIGNED16	0 – 1023	AD1 – the raw input of the first ADC channel. Reflects (0-5) V
3, 4	SIGNED16	0 – 1023	AD2 – the raw input of the second ADC channel. Reflects (0-5) V
5, 6	SIGNED16	0 – 1023	AD3 – the raw input of the spool position channel (third ADC channel). Reflects (0-5) V
7, 8	SIGNED16	-1000 – 1000	Xsp – the calculated spool position set-point. Reflects -7 – 7 mm spool travel

Status

Set no. 2

Bytes	Encoding	Value/Range	Description
1, 2	SIGNED16	-1000 – 1000	Yact – scaled steering actuator position. Reflects -100.0% – 100.0% where 0.0% indicates the middle of the cylinder
3, 4	SIGNED16	-1000 – 1000	Yset – commanded actuator position set-point (closed loop control) or commanded actuator speed set-point (open loop control)
5, 6	SIGNED16	-1000 – 1000	Q – the port flow command. Reflects the range 100% at CL port to 100% at CR port
7, 8	UNSIGNED16	0x00 0x01 0x02 0x03 0x04 0x05	Selected device: – no device selected – steering wheel – reserved – high priority steering device – low priority steering device – high priority set-point controller

Set no. 3

Bytes	Encoding	Value/Range	Description
1, 2	SIGNED16	-1000 – 1000	Xsp – the calculated spool position set-point. Reflects -7 – 7 mm spool travel
3, 4	SIGNED16	-1000 – 1000	Scaled spool position. Reflects -7 – 7 mm spool travel
5, 6	UNSIGNED16	0 – 4095	wheel angle (scaled Yact) 0 – left endlock 2047 – pointing straight ahead 4095 – right endlock
7, 8	UNSIGNED16	0 - 59999	timestamp – a value of a millisecond timer that starts counting upon PVED-CL power-on and rolls over after one minute. 1 ms unit, accuracy equal to 5 ms

Set no. 4

Bytes	Encoding	Value/Range	Description
1, 2	UNSIGNED16	0 – 9990	Sensor supply voltage [mV]
3, 4	SIGNED16	-1000 – 1000	Scaled spool Position Reflects -7 – 7 mm spool travel
5, 6	SIGNED16	-50 – 451	PVED-CL temperature [deg. C]
7, 8	UNSIGNED16	13 – 35534	Battery supply voltage [mV]

StartStopOperationStatus

The command is used to make PVED-CL start/stop sending operation status information. Power-on state: operation status enabled.

CAN message

Priority	6
PGN	61184
XID	0x0FAC (MSB first)

Status

CAN message (continued)

Occurrence	when required
Modes	operational, reduced, fault
Sent by	configuration tool
Sent to	PVED-CL

Data field

Bytes	Encoding	Value/Range	Description
1, 2	UNSIGNED16	0x0FAC (MSB first)	extended message identifier (XID)
3	UNSIGNED8	0x00 0x0FF	stop sending operation status information request for operation status

OperationStatus

Used for broadcasting the information about selected device, chosen program and steering devices status.

CAN message

Priority	6
PGN	65280 + offset_base + 1
XID	n/a
Occurrence	every 240 ms. Only if Operation Status messages are enabled
Modes	operational, reduced, fault
Sent by	PVED-CL
Sent to	all nodes

Data field

Bytes	Encoding	Value/Range	Description
1	UNSIGNED8	 0x0AA 0x0AF 0x0FF	*Current mode*: – operational – reduced – fault
2	UNSIGNED8	 0x00 0x01 0x02 0x03 0x04 0x05	*Selected device*: – no device selected – steering wheel – reserved – high priority steering device – low priority steering device – high priority external set-point controller
3	UNSIGNED8	(depends on the selected device)	Active program. 0x0FF if no device is selected
4	UNSIGNED8	 0x00 0x03 0x53 0x0A3 0x0F3	*High priority steering device status*: – device not mapped – device enabled – device enabled. Change armed – device disabled – device disabled. Change armed

Status

Data field (continued)

Bytes	Encoding	Value/Range	Description
5	UNSIGNED8	0x00 0x04 0x54 0x0A4 0x0F4	*Low priority steering device status*: – device not mapped – device enabled – device enabled. Change armed – device disabled – device disabled. Change armed
6	UNSIGNED8	0x00 0x05 0x55 0x0A5 0x0F5	*High priority external set-point controller*: – device not mapped – device enabled – device enabled. Change armed – device disabled – device disabled. Change armed
7	bits 8 - 5	all zeros	Not used
	Reduced mode caused by problems with:		
	bit 4	0 1	*Wheel angle sensor signal*: – no – yes
	bit 3	0 1	*Vehicle speed signal*: – no – yes
	bit 2	0 1	*High priority steering device*: – no – yes
	bit 1	0 1	*Low priority steering device*: – no – yes

TimeReport

This message is used to provide other nodes with an absolute measure of time since the PVED-CL was booted. It can be used for diagnostic purposes and for resolving any rollover ambiguities in the timestamp information available in the Status message – set no. 3.

CAN message

Priority	6
PGN	65280 + offset_base + 2
XID	n/a
Occurrence	every 1 s
Modes	operational, reduced
Sent by	PVED-CL
Sent to	all nodes

Data field

Bytes	Encoding	Value/Range	Description
1, 2	UNSIGNED16	0 – 59999	timestamp – a value of a timer that starts counting upon PVED-CL power-on and rolls over after one minute. 1 ms unit. Accuracy equal to 5 ms.
3 – 6	UNSIGNED32	0 – 357913	number of rollovers, since boot, of a millisecond timer

Control

SetSpoolPosition

Used to transmit the spool position set-point to the PVED-CL.

CAN message

Priority	6
PGN	61184
XID	0x0FAD (MSB first)
Occurrence	when required
Modes	calibration
Sent by	configuration tool
Sent to	PVED-CL

Data field

Bytes	Encoding	Value/Range	Description
1, 2	UNSIGNED16	0x0FAD (MSB first)	extended message identifier (XID)
3, 4	SIGNED16	-1000 – 1000	requested spool position, reflects -7 – 7 mm spool travel

SetFlow

Used for transmitting a flow request to the PVED-CL. The flow request is converted to a spool position with dead-band compensation. Use the SetFlow command for black-box testing the PVED-CL flow characteristic in operational mode without knowledge to the actual dead-band settings.

Open-loop mode converts the flow request directly to the corresponding spool position with dead-band compensation.

Closed-loop mode converts the flow request as for open-loop mode but adds the programmed closed loop spool position offset (ClosedLoopXspOffset at parameter index 748) to the spool position. This allows testing the valve output flow when used in Guidance mode.

CAN message

Priority	6
PGN	61184
XID	0x0FB8 (MSB first)
Occurrence	when required
Modes	calibration
Sent by	configuration tool
Sent to	PVED-CL

Data field

Bytes	Encoding	Value/Range	Description
1, 2	UNSIGNED16	0x0FB8 (MSB first)	extended message identifier (XID)

Control

Data field (continued)

Bytes	Encoding	Value/Range	Description
3, 4	SIGNED16	-1000 – 1000 -1000 -1 1 1000	requested flow – corresponds to max flow to the left – corresponds to minimum flow to the left – corresponds to minimum flow to the right – corresponds to max flow to the right
5	UNSIGNED8	0 255	Apply open-loop flow-to-spool-position scaling Apply closed-loop flow-to-spool-position scaling

StartValveAutoCalibration

Used for performing an auto-calibration of the PVED-CL to the valve. The valve dead-bands are automatically found and stored in the PVED-CL.

Auto-calibration may be useful for fine-tuning the PVED-CL and the valve when installed in its final environment.

This ensures optimum open-loop and closed-loop steering performances.

Auto-calibration is also useful if the PVED-CL needs to be replaced in the field.

CAN message

Priority	6
PGN	61184
XID	0x0FB6 (MSB first)
Occurrence	when required
Modes	calibration
Sent by	MMI
Sent to	PVED-CL

Data field

Bytes	Encoding	Value/Range	Description
1, 2	UNSIGNED16	0x0FB6 (MSB first)	extended message identifier (XID)
3, 4	UNSIGNED16	0 – Max	XspStartSearch – the spool position set-point (Xsp) at which the auto-calibration starts. Max = 250 + XspCalibrationOffset XspCalibrationOffset is the parameter value stored at parameter index 758.
5	UNSIGNED8	1 – 255	XspIncrementSize – the spool position set-point increment size (ΔXsp) while searching for the specified minimum steered wheel position (Yact) difference.
6	UNSIGNED8	1 – 255	YactDiffThreshold – the minimum steered wheel position (Yact) difference threshold The difference is measured in the time-out period.
7, 8	UNSIGNED16	1 – 65535	Time-out period - defines the time [ms] that each spool position set-point is active in before the next increment.

Control

Data field (continued)

Bytes	Encoding	Value/Range	Description
The spool position set-point unit is a scaled value in the range -1000 to 1000, corresponding from -7 to 7 mm nominally. The scaled steering actuator position/steered wheel position (Yact) range is -1000 to 1000, corresponding to the steered wheel end-lock positions. Requires that the wheel angle sensor is correctly calibrated.			

ValveAutoCalibrationStatus

The message is transmitted as a response to the StartValveAutoCalibration command. Allows monitoring the progress and status of the valve auto-calibration.

CAN message

Priority	6
PGN	61184
XID	0x0FB7 (MSB first)
Occurrence	During auto-calibration after each time-out period, at commit state change, at status information change
Modes	Calibration
Sent by	PVED-CL
Sent to	MMI

Data field

Bytes	Encoding	Value/Range	Description
1, 2	UNSIGNED16	0x0FB7 (MSB first)	extended message identifier (XID)
3	UNSIGNED8		*Related to StartValveAutoCalibration command:*
		0x00	– invalid auto-calibration request
		0x01	– invalid starting spool position set-point request
		0x02	– invalid spool position set-point increment size request
		0x03	– invalid minimum wheel angle difference threshold request
		0x04	– invalid time-out period value request
			Auto-calibration status/error codes:
		0x05	– invalid wheel position for further auto-calibration related activities
		0x06	– missing steering wheel sensor signal
		0x07	– steering wheel in use
		0x08	– missing steered wheel feedback sensor signal
		0x09	– wheels found moving for the starting spool position set-point
		0x0A	– wheels not moving at maximum allowed spool position (right direction)
		0x0B	– wheels not moving at maximum allowed spool position (left direction)
		0x0C	– unable to update dead-band parameters
		0x0D	– the previously requested commit data process has not finished yet
		0x0E	– commit data process has failed due to the cross-parameter check failure
		0x0F	– commit data process has failed due to the EEPROM write failure
		0x10	– commit data process has not started on time
		0x11	– commit data process has not finished on time
		0xA0	– unknown error (contact technical support)
		0xA1	– the commit data process has started
		0xAA	– auto-calibration in progress
		0xFF	– auto-calibration completed
4, 5	SIGNED16	-1000 – 1000	Xsp - current main spool position

Control

A typical successful valve auto-calibration message sequence:

MMI.StartValveAutoCalibration → PVED-CL

PVED-CL.ValveAutoCalibrationStatus.auto-calibration in progress → MMI

PVED-CL.ValveAutoCalibrationStatus.auto-calibration in progress → MMI

...

PVED-CL.ValveAutoCalibrationStatus.auto-calibration in progress → MMI

PVED-CL.SetParameterResponse.right dead-band value (index 738) → MMI

PVED-CL.ValveAutoCalibrationStatus.auto-calibration in progress → MMI

PVED-CL.SetParameterResponse.left dead-band value (index 737) → MMI

PVED-CL.ValveAutoCalibrationStatus.auto-calibration in progress → MMI

PVED-CL.SetParameterResponse.right maximum value (index 747) → MMI

PVED-CL.ValveAutoCalibrationStatus.auto-calibration in progress → MMI

PVED-CL.SetParameterResponse.left maximum value (index 729) → MMI

PVED-CL.CommitDataResponse.Commit operation has just begun → MMI

PVED-CL.ValveAutoCalibrationStatus.Commit process has started → MMI

PVED-CL.CommitDataResponse.Commit succeeded → MMI

PVED-CL.ValveAutoCalibrationStatus.auto-calibration completed → MMI

SelectProgram

Used for requesting the program change for a defined steering device.

CAN message

Priority	6
PGN	61184
XID	0x0FAE (MSB first)
Occurrence	when required
Modes	operational, reduced
Sent by	MMI
Sent to	PVED-CL

Data field

Bytes	Encoding	Value/Range	Description
1, 2	UNSIGNED16	0x0FAE (MSB first)	extended message identifier (XID)
3	UNSIGNED8	0 – 9 20 – 24 25 – 29 30 – 34	program number for: – steering wheel – high priority steering device – low priority steering device – high priority external set-point controller

Control

SelectProgramResponse

The message is transmitted upon the **SelectProgram** command to inform whether the program transition was successful. If the transition has not been allowed, the active program number will point at the previous and still valid program.

CAN message

Priority	6
PGN	61184
XID	0x0FAF (MSB first)
Occurrence	upon request
Modes	operational, reduced
Sent by	PVED-CL
Sent to	MMI

Data field

Bytes	Encoding	Value/Range	Description
1, 2	UNSIGNED16	0x0FAF (MSB first)	extended message identifier (XID)
3	UNSIGNED8	as for **SelectProgram**	requested program number
4	UNSIGNED8	as for **SelectProgram**	active program number (for the requested device) or 0x0FF if a non-existing program has been requested

DisableSteeringDevice

The command is used to disable/enable any mapped steering device, but steering wheel.

The message is ignored if the OSP (hydraulic backup) is not present.

Disabled devices are not taken into account while making a decision which steering device should control the vehicle. However, the plausibility checks related to these devices will be performed.

Please note that disabling the device currently selected for steering results in “no device selected” condition.

CAN message

Priority	6
PGN	61184
XID	0x0FB0 (MSB first)
Occurrence	when required
Mode	operational, reduced
Sent by	MMI
Sent to	PVED-CL

Data field

Bytes	Encoding	Value/Range	Description
1, 2	UNSIGNED16	0x0FB0 (MSB first)	extended message identifier (XID)

Control

Data field (continued)

Bytes	Encoding	Value/Range	Description
3	SIGNED16	0x53 0x03 0x0A3 0x54 0x04 0x0A4 0x55 0x05 0x0A5	Command: – arm high priority steering device enabling/ disabling – enable high priority steering device – disable high priority steering device – arm low priority steering device enabling/disabling – enable low priority steering device – disable low priority steering device – arm high priority external set-point con. enabling/ disabling – enable high priority external set-point controller – disable high priority external set-point controller.

DisableSteeringDevice Response

The message is transmitted upon the **DisableSteeringDevice** command to inform whether the operation succeeded.

However, as **DisableSteeringDevice** command is ignored when the OSP is not present, in this case no response will be sent back.

CAN message

Priority	6
PGN	61184
XID	0x0FB1 (MSB first)
Occurrence	upon request, on timeout
Mode	operational, reduced
Sent by	PVED-CL
Sent to	MMI

Data field

Bytes	Encoding	Value/Range	Description
1, 2	UNSIGNED16	0x0FB1 (MSB first)	extended message identifier (XID)
3	UNSIGNED8	0x00 0x03 0x53 0x0A3 0x0F3	High priority steering device status: – device not mapped – device enabled – device enabled. Change armed – device disabled – device disabled. Change armed
4	UNSIGNED8	0x00 0x04 0x54 0x0A4 0x0F4	Low priority steering device status: – device not mapped – device enabled – device enabled. Change armed – device disabled – device disabled. Change armed
5	UNSIGNED8	0x00 0x05 0x55 0x0A5 0x0F5	High priority external set-point controller: – device not mapped – device enabled – device enabled. Change armed – device disabled – device disabled. Change armed

Guidance

GuidanceSystemCommand

This message conforms to ISO 11783-7 guidance commands. It is used for auto-steering and commands the vehicle to follow the transmitted curvature course.

Negative curvature values will cause the vehicle to drive left.

CAN message

Priority	3
PGN	44288
XID	n/a
Occurrence	when required, every 100 ms or faster. PVED-CL sample period is 20 ms
Mode	operational, reduced
Sent by	high priority external set-point controller
Sent to	PVED-CL

Data field

Bytes	Encoding	Value/Range	Description
1, 2	UNSIGNED16	0 – 64255	curvature command (-8032 to 8031.75) km-1 with resolution 0.25 km-1 and offset -8032 km-1
3	bits 8-3	all ones	reserved
	bits 2, 1	00 01 10 11	steering command status: – not intended for steering – intended for steering – error indication – not available
4 – 8	–	all ones	reserved

GuidanceMachineStatus

This message conforms to ISO 11783-7 guidance commands. It is used to report current vehicle's estimated curvature as well status flags.

CAN message

Priority	3
PGN	44032
XID	n/a
Occurrence	every 80 ms, only if the high priority external set-point controller is mapped
Mode	operational, reduced
Sent by	PVED-CL
Sent to	high priority external set-point controller

Guidance

Data field

Bytes	Encoding	Value/Range	Description
1, 2	UNSIGNED16	0 – 64255	Estimated curvature: (-8032 to 8031.75) km^{-1} with resolution 0.25 km^{-1} and offset -8032 km^{-1}
3	bits 8, 7	00 01 10 11	Request reset command status: – reset not required – reset required – error indication – not available
	bits 6, 5	00 01 10 11	Steering input position status: – incorrect position – correct position – error indication – not available
	bits 4, 3	00 01 10 11	Machine can execute commands: – system is not ready – system is ready – error indication – not available
	bits 2, 1	00 01 10 11	Mechanical system lockout: – not active – active – error indication – not available
4 – 8	–	all ones	Reserved

Please note that when PVED-CL requests the GPS reset (byte 3, bits 8-7), it waits for at least one **GuidanceSystemCommand** message not intended for steering.

Diagnostics (proprietary)

GetErrorEntry

The command is used to retrieve the data stored in error buffers.

CAN message

Priority	3
PGN	61184
XID	0x0FB3 (MSB first)
Occurrence	when needed
Modes	operational, reduced, calibration and fault
Sent by	configuration tool
Sent to	PVED-CL

Data field

Bytes	Encoding	Value/Range	Description
1, 2	UNSIGNED16	0x0FB3 (MSB first)	extended message identifier (XID)
3	UNSIGNED8	1 – 16	buffer index (the oldest error at index 1)
4	UNSIGNED8	0 1 2	Request details – error code – timestamp when error occurred since power on – PVED-CL PCB temperature when error occurred

GetErrorEntryResponse

The message presents data available in the error log.

CAN message

Priority	6
PGN	61184
XID	0x0FB4 (MSB first)
Occurrence	upon request
Modes	operational, reduced, calibration and fault
Sent by	PVED-CL
Sent to	configuration tool

Data field (error identification data)

Bytes	Encoding	Value/Range	Description
1, 2	UNSIGNED16	0x0FB4 (MSB first)	extended message identifier (XID)
3	UNSIGNED8	1 – 16	buffer index (the oldest error at index 1)
4	UNSIGNED8	0	error code details
5	UNSIGNED8	0 0x55 0xAA 0xFF	error severity: – caution – nominal – critical – wrong index or no information available

Diagnostics (proprietary)

Data field (error identification data) (continued)

Bytes	Encoding	Value/Range	Description
6–7	UNSIGNED16	0 – 0xFFFE 0xFFFF	– error code – wrong index or information not available

Data field (timestamp)

Bytes	Encoding	Value/Range	Description
1, 2	UNSIGNED16	0x0FB4 (MSB first)	extended message identifier (XID)
3	UNSIGNED8	1 – 16	buffer index (the oldest error at index 1)
4	UNSIGNED8	1	timestamp details
5–8	UNSIGNED32	0 – 0xFFFFFFFE 0xFFFFFFFF	timestamp: – the value of a timer which starts counting upon PVED-CL power-on, observed when the error occurred – wrong index or no information available

Data field (temperature)

Bytes	Encoding	Value/Range	Description
1, 2	UNSIGNED16	0x0FB4 (MSB first)	extended message identifier (XID)
3	UNSIGNED8	1 – 16	buffer index (the oldest error at index 1)
4	UNSIGNED8	2	temperature details
5–6	SIGNED16	-50 – 150 150 – 450 -32768	PVED temperature: – temperature in oC, observed when the error occurred – temperature sensor provided data, but was likely to be damaged by being oveheated – wrong index or no information available

ClearErrorEntries

Used for clearing all error entries in the persistent error buffer.

CAN message

Priority	6
PGN	61184
XID	0x0FB5 (MSB first)
Occurrence	when needed
Modes	operational, reduced, calibration
Sent by	configuration tool
Sent to	PVED-CL

Data field

Bytes	Encoding	Value/Range	Description
1, 2	UNSIGNED16	0x0FB5 (MSB first)	extended message identifier (XID)

Diagnostics (proprietary)

Commit Error Code

Commit Error codes from CommitDataResponse message

Commit Error Code	Parameter Consistency Check Fail
11150	Vehicle speed dependant parameter conflict. One or more steering wheel programs do not comply with the rule sts0 ≤ sts1 ≤ sts2 ≤ sts3 ≤ sts4 ≤ sts5.
11151	Vehicle speed dependant parameter conflict. One or more programs for high priority steering device, low priority steering device or high priority external set-point controller, the sensitivity parameters do not comply with the rule sts0 ≥ sts1 ≥ sts2 ≥ sts3 ≥ sts4 ≥ sts5.
11152	OSP and EHPS valve parameter conflict. One or more steering wheel programs do not comply with the rule that sensitivity parameters (Sts0-Sts5) shall be < OSP (back-up) sensitivity.
11153	OSP and EHPS valve parameter conflict. The backlash parameter Ri shall be ≤ RiOSP.
11154	Closed-loop parameter conflict. YR must be 1000 for programs where the control principle Cp is “Closed loop”.
11155	Closed-loop parameter conflict. YL must be 1000 for programs where the control principle Cp is “Closed loop”.
11156	OSP and EHPS valve conflict. For steering wheel programs, Qm must be 1000.
11160	Primary and secondary wheel angle sensor conflict. No primary wheel angle sensor is mapped.
11161	Db and Xysat parameter conflict. Db must be ≥ xysat.
11162	Analogue input AD1 parameter conflict. For linear (3-point) AD1 calibration the following rule must be followed: AD1_1000_Left (index 65080) < AD1_Neutral (index 65086) < AD1_1000_Right (index 65083) or AD1_1000_Left > AD1_Neutral > AD1_1000_Right
	For linear (5-point) AD1 calibration the following rule must be followed: AD1_1000_Left < AD1_500_Left (index 65055) < AD1_Neutral < AD1_500_Right (index 65062) < AD1_1000_Right or AD1_1000_Left > AD1_500_Left > AD1_Neutral > AD1_500_Right > AD1_1000_Right
11163	Analogue input AD2 parameter conflict. For linear (3-point) AD2 calibration the following rule must be followed: AD2_1000_Left (index 65089) < AD2_Neutral (index 65095) < AD2_1000_Right (index 65092) or AD2_1000_Left > AD2_Neutral > AD2_1000_Right
	For linear (5-point) AD2 calibration the following rule must be followed: AD2_1000_Left < AD2_500_Left (index 65069) < AD2_Neutral < AD2_500_Right (index 65076) < AD2_1000_Right or AD2_1000_Left > AD2_500_Left > AD2_Neutral > AD2_500_Right > AD2_1000_Right
11164	Closed loop mode with no wheel angle sensor conflict. Closed loop program for high or low priority steering device or external set-point controller are configured but no wheel angle sensor is mapped.
11165	J1939 Source address parameter conflict. **PvedSourceAddress**, **VehicleSpeedSensorSourceAddress**, **ControlDeviceSourceAddress**, **ConfigurationDeviceSourceAddress**, and **HPExtSourceAddress** (index 64003 to 64007) have to differ from each other.
11166	Device enable/disable initialization conflict. When no OSP is mapped, all mapped steering devices must be enabled at boot-up (index 64008 to 64010).
11167	Rate limitation parameter conflict. When fast ramp down is utilized, Tfo (index xy23) and Tfh (index xy24) must be higher than Tfr (index xy33)
11168	Analogue input mapping conflict. Two sensors are mapped to the same AD input.

Diagnostics (proprietary)

Commit Error codes from CommitDataResponse message (continued)

Commit Error Code	Parameter Consistency Check Fail
11169	AD1/AD2 analogue input compensation error. The 5V ext reference stored for compensation is out of range.
11170	Articulated vehicle length parameter is out of range. Total length cannot exceed 65535 mm.
11171	Actuator dependant steering sensitivity parameter conflict. One or more program utilizes actuator dependant steering sensitivity but no wheel angle sensor is mapped.
11172	Vehicle speed dependant steering sensitivity parameter conflict. One or more program utilizes vehicle speed dependant steering sensitivity but no wheel speed sensor is mapped.
11173	**StwDxActivationThreshold** parameter conflict. StwDxActivationThresold (index 64022) needs to be greater than or equal to the steering wheel position difference corresponding to the min motion needed to make the steering wheel selected for steering. The follow equation shall be true: $\text{StwDxActivationThreshold} \geq \frac{\text{Steering\_Motion\_Threshold} \cdot 4095}{10 \cdot \text{Full\_Strk} \cdot \text{Period}}$ *Where*: Steering_Motion_Threshold is defined in parameter index 119. Full_Strk is defined in parameter 111. Period is the SASA transmission period. Set Period = 5, 10 or 20 if STWSensor-TransmissionRate is 20, 10 or 5 ms respectively. STWSensorTransmissionRate is defined in parameter index 65124.
11176	The spool position dead-band parameter (Xspr_0 or Xspl_0) value is out of range for the selected valve type.
11177	The maximum allowed spool position parameter (Xspr_1000 or Xspl_1000) is out of range for the selected valve type.

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