ENGINEERING
TOMORROW

Software Manual

Digital Displacement® Pump
Software Version 2.8.1

Revision history

Date	Changed	Rev
November 2022	Updated for software release 2.8.1	0201
February 2022	Corrected small errors in sections 9.3 and 9.5.1.4.2	0102
August 2021	First edition: software release 2.7.1	0101

Contents

1 Release notes

1.1 Version 2.8.1

- New naming convention adopted for software variants
- Unsupported DD configuration error removed
  - All control mode, control reference source and limit source combinations are now supported
- Added build for three-service pumps (AC)
- Improved commissioning mode support for three-service software and service switching
- Added multiple simultaneous valve pumping and selectable stroke count support in commissioning mode
- Removed read-only parameters from writable parameters list for PLUS+1® Service Tool
- Added software identification and ECU identification J1939 PGN support
- *No changes were made to the J1939 protocol, other than the additions above*

1.2 Version 2.7.1

- Reorganized J1939 protocol
  - Changed PGN framing to conform to Danfoss product compatibility standard
  - Changed scaling for SPNs to use standard SLOTs where possible
- Added J1939 address claim procedure support
  - New parameter for controller instance
  - New errors for address claim failures
- Improved PLUS+1® Service Tool info block details
- Service switching configuration can be set from PLUS+1® (as well as J1939)
- Added parameter to read FPGA version
- Added additional supported use cases
  - Single-service
    - Displacement control by PLUS+1®
    - Displacement control by PLUS+1® with torque limit
  - Two-service
    - Displacement control by PLUS+1®
    - Displacement control by PLUS+1® with torque limit
    - Industrial pressure control by J1939 with flow limit
    - Industrial pressure control by J1939 with flow limit and PLUS+1® service configuration
    - Industrial pressure control by PLUS+1® with flow limit
    - Load-sense pressure control by J1939 with torque limit
    - Load-sense pressure control by PLUS+1® with torque limit
    - Mixed displacement/load-sense by J1939

1.3 Version 2.6.3 (originally labeled 2.63)

- Added build for two-service pumps (ML)
- Changed layout of control reference and limit parameters from using enable parameters (EN_x) to source parameters (x_SRC)
- Added additional supported single-service use cases
  - Displacement control by J1939
  - Displacement control by J1939 with torque limit
  - Industrial pressure control by PLUS+1®
  - Industrial pressure control by PLUS+1® with flow limit
  - Load sensing pressure control by PLUS+1®
  - Load sensing pressure control by J1939
  - Load sensing pressure control by PLUS+1® with torque limit
  - Load sensing pressure control by J1939 with torque limit

1.4 Version 2.5.1 (originally labeled 2.51)

- First release for single-service pumps (SS)

2 Known issues

2.1 CAN Bus Off error after turning on a DPC12 (193548)

2.1.1 Description

Other devices on the bus experience CAN faults which may cause them to declare a CAN Bus Off error after the DPC12 controller is powered on. This causes the devices to stop communicating with the system until their faults are cleared.

The issue may also lead to difficulty using the PLUS+1® Service Tool Recover ECU function as controller is power cycled during this procedure.

The problem is caused by the power-up behavior of the DPC12 CAN transmitter. When the controller is supplied from a current-limited power supply, the controller can hit this current limit and brown out multiple times during the initial power-up. On each brownout an erroneous signal is transmitted on the CAN bus. Multiple brownouts lead to a high enough error count to trigger the CAN Bus Off error on other connected devices.

2.1.2 Solutions

Use a power supply with a higher current limit or turn off soft-start behavior.

A hardware solution will be implemented in a future DPC12 controller revision.

2.2 Controller does not boot with miswired CAN bus cable (447376)

2.2.1 Description

Connecting a miswired CAN bus cable to the DPC12 controller can cause the DDP096 software to fail to boot and enter an operable state.

2.2.2 Solutions

Remove CAN bus cable and ensure DPC12 controller boots by verifying status LED.

Fix CAN bus wiring.

2.3 Not all error counters cleared by `RESET_ERR_CNTR_CMD` (338706)

2.3.1 Description

When using the `RESET_ERR_CNTR_CMD` parameter or DM3 PGN - diagnostics data clear of previously active DTCs to reset the error occurrence counters soon after start-up, not all counters are reset.

2.3.2 Solutions

Wait at least 30 seconds after powering on the DPC12 controller to clear the error counters.

2.4 PLUS+1® parameter value cannot be changed if its source is not set to 1 (346303)

2.4.1 Description

PLUS+1® parameters which are read/write or read-only depending on the setting of the corresponding source parameter (_SRC) cannot be changed until the source is set to PLUS+1®.

This issue is particularly apparent when downloading parameters from an XML file in Service Tool.

2.4.2 Solutions

Ensure that the corresponding source parameter is set to PLUS+1® before writing to the parameter. If downloading an XML file in Service Tool, arrange the parameters so that the source parameter comes earlier in the list than the parameter.

2.5 Pressure sensor invalid low error with sensor connected (361396)

2.5.1 Description

A pressure sensor invalid low error can be triggered at low pressure in an electrically noisy environment. The following errors may be seen:

- Service 1 outlet pressure reading below minimum (SPN 520960, FMI 18)
- Service 2 outlet pressure reading below minimum (SPN 520961, FMI 18)
- Service 3 outlet pressure reading below minimum (SPN 520962, FMI 18)
- Service 1 external load-sense pressure reading below minimum (SPN 521020, FMI 18)
- Service 2 external load-sense pressure reading below minimum (SPN 521021, FMI 18)
- Service 3 external load-sense pressure reading below minimum (SPN 521022, FMI 18)

2.5.2 Solutions

Contact Danfoss for advice.

2.6 Software update fails when using multiple CAN bus devices (400960)

2.6.1 Description

Downloading new software to the DPC12 controller using the PLUS+1® Service Tool can fail when other CAN bus devices are communicating on the bus.

2.6.2 Solutions

Disconnect or power-down other CAN bus devices on the bus before updating the controller software.

If download failure occurs, follow the above advice and use the Recover ECU feature in the PLUS+1® Service Tool to retry the download.

2.7 Upgrading from version 2.5.1 introduces unexpected parameter changes (734495)

2.7.1 Description

When upgrading from software version 2.5.1 on a controller which has previously been programmed with version 2.6.x or later, the parameters previously saved under the higher software version can unexpectedly be restored. This includes the BAUD_RATE parameter, which can cause the controller to set its CAN port to a baud rate which is not the value in use before the upgrade or the default value.

2.7.2 Solutions

If the PLUS+1® Service Tool connection is not restored after upgrading from version 2.5.1, isolate the DPC12 controller from other devices on the CAN bus then try each baud rate option in turn until connection is restored. The baud rate can then be adjusted in Service Tool. Check all parameters are correct after all software upgrades.

2.8 Two CG150 gateways causes communications error (404422)

2.8.1 Description

When two Danfoss CG150-2 CAN/USB interface gateway devices are present on the DPC12's CAN network parameter write operations may fail.

2.8.2 Solutions

Ensure only one CG150 device is used on the CAN network connected to the DPC12.

3 Software variants

The DDP096 software is supplied in different builds, each designed for a different pump configuration.

- AA: a DDP096S (single pump) providing flow to a single hydraulic service.
- AB: a DDP096S (single pump) providing flow to two hydraulic services.
- AC: a DDP096S (single pump) providing flow to three hydraulic services.

For further information on multiple service operation see the Multi-service operation section.

The DDP096 software is supplied pre-installed on the DPC12 controller. The software build and version of the software supplied on the DPC12 controller is represented by the "Software Build" and "Software Version" fields of the DDP096 Master Model Code. Please contact your Danfoss representative for advice on selecting the correct software for your application.

3.1 File names

Updates to the DDP096 software are supplied as two files, a `.hex` file and a `.plg` file, with matching file names. The file name format is

```
DDP-[controller type]-[software build]-[software version]_[revision]_[build
date]_[build time].hex
```

for instance

```
DDP-A1-AA-01023_r12345_20211231_2359.hex
```

In this example,

- The controller type is A1, representing a DPC12 (this is the "Electronic Hardware" field of the DDP096 Master Model Code).
- The software build is AA, representing single service DDP096S software.
- The software version is 01023, representing version 1.2.3. The identifier ALPHA is used for unreleased test builds of the software.
- The revision is r12345, representing a particular revision of the source code. This field is used for internal tracking.
- The build date is 20211231, representing the 31st December 2021.
- The build time is 2359, representing 23:59.

The PLUS+1® Service Tool shows information on the application installed on a DPC12 controller, matching the relevant fields in the file name:

- "Application ID" shows "DDP" and the controller type and software build.
- "Application Version" shows the software version.
- "Compile Time" shows the build date and time.

4 Configuring a new controller

The DDP096 is a software-driven product and requires initial configuration to operate correctly in a hydraulic system or vehicle. The following items should be considered when setting up the DPC12 controller for the first time. Failure to do so may result in the pump being unable to operate reliably.

If you have any issues or require assistance with the initial setup, please contact your Danfoss representative.

4.1 Use of a CAN Bus

The DDP096 software is designed to be setup and monitored using a CAN bus. It is recommended that a diagnostic connector is available in every installation including a DPC12 controller.

The DDP096 software includes an error to detect electrical problems with the CAN bus during operation. This error will be triggered in a system where no CAN bus is connected to the controller while it is operating. To prevent the error being triggered and the pump disabled, the `IGNORE_EPV_FLAG` parameter must be changed from its default value. See the Communication parameters and Errors sections for further details.

⚠ Warning

Parameter `IGNORE_EPV_FLAG` must be set to 1 if no CAN bus connection is present in operation.

The DPC12 controller must be able to be uniquely addressed when using a J1939 CAN bus for control or monitoring. For this it implements the J1939 address claim procedure. Details of this procedure should be understood as address claim errors will result in the pump being disabled. See the Address scheme and Errors sections for further details.

⚠ Warning

If more than one DPC12 is connected to the CAN bus the controllers must be uniquely addressed.

4.2 Control configuration required

The factory default setting for the DPC12 controller sets the control method to a static displacement of zero output. The DDP096 software must be configured to the control method required by the hydraulic system or vehicle. See the Control configuration section for more details.

4.3 Control loop gains

A control loop with tunable gains is used by the software in pressure control and load-sense control modes. These gains must be tuned to match the hydraulic characteristics of the system and the desired pump response. It is recommended to undergo training or receive assistance from your Danfoss representative when doing first start-up of a new hydraulic system operating in either of these modes to ensure that the control loop gains can be tuned for optimal system performance and response.

4.4 PLUS+1® Service Tool

The Danfoss PLUS+1® Service Tool is used to configure the DDP096 software. Service Tool pages are available to make interacting with the DDP096 software parameters simple. The Service Tool can be downloaded from the Danfoss website. Please contact your Danfoss representative for access to the DDP096 Service Tool pages.

4.5 Backup parameters

It is highly advisable to backup the DDP096 software parameters once setup is complete. In the event of damage to the DPC12 controller or non-volatile memory corruption the backup parameters can be downloaded to a new DPC12 controller to allow the DDP096 pump to function as desired. Please contact your Danfoss representative for training on using the PLUS+1® Service Tool to export parameters from a DPC12 controller.

Warning

Danfoss and the PLUS+1® Service Tool do not automatically store copies of DDP096 software parameters. Backups should be made after the configuration is changed.

5 Commissioning mode

The DDP096 software includes a commissioning mode which is used to exercise pumping units when the pump is not in normal operation. More detail on commissioning a DDP096 pump and DPC12 in a hydraulic system is provided in the Digital Displacement® Pump Gen 1 DDP096 and DPC12 Technical Information.

⚠ Warning

Some error protection is disabled in commissioning mode. The user should ensure that the system is properly protected hydraulically (for instance with a pressure relief valve on each outlet) and is monitored carefully throughout.

5.1 Entering and exiting commissioning mode

Commissioning mode is entered by setting the EN_COMMISS parameter to "enabled" (1) and power cycling the controller. The DEVICE_MODE parameter can be used to check that the DDP096 software is in commissioning mode - the value will be 2 when in commissioning mode.

Commissioning mode is left by setting the EN_COMMISS parameter back to "disabled" (0) and power cycling the controller.

5.2 Commissioning actions

Five actions are available to the user in commissioning mode:

- fire
- pump
- service configuration change
- raw displacement, service 1
- raw displacement, service 2
- raw displacement, service 3

Each is described in the following sections.

To set up an action:

1. the COMMISS_ACT_TYPE_1 parameter should be set to the value corresponding to the particular action.
2. the COMMISS_ACT_TYPE_2 parameter should be set to the required value to enable one or more coils for the next fire/pump action.
3. the COMMISS_VALUE_1 parameter should be set to the required number of pumping strokes or service configuration index or displacement percentage.
4. the COMMISS_CMD parameter should be set to 1 to start the action.
5. the COMMISS_CMD parameter should be set back to 0 when the action is complete before starting the next action.

Each action may be disabled due to the current shaft speed or active errors. The DDP096 software shows which actions are allowed via the COMMISS_LEVEL parameter, which has three levels:

0. Internal 24V power supply problem, including no power to coil supply pins, is indicated by the ERR_AE_3599_02_LM_OUT24V error being active.
1. At least one severe error active (other than ERR_AE_3599_02_LM_OUT24V).
2. No severe errors active.

When an action is requested, the DDP096 software reports the result of the request with the COMMISS_STATUS parameter. It shows whether a request was denied and whether the action is in progress. The request can be denied when:

- the COMMISS_LEVEL is lower than that required for the requested command
- a number of pumping strokes outside of the allowed range is requested for the pump command
- the service configuration index given is invalid for the service configuration change command

For fire and pump actions with a low number of pumping strokes and for service configuration changes, the

parameter is set to the in progress value only for a very short time.

5.2.1 Fire

The fire action allows the coils of a particular set of pumping units to be energized. This is intended to allow the user to check for correct wiring to the coils, either by listening for the audible click produced during the energization or by using a current probe to view the current in the wires to the coils.

COMMISS_ACT_TYPE_1 is 1 for the fire action and the COMMISS_ACT_TYPE_2 parameter selects the coils to be fired (see Coil enabling section).

The fire action is available whether or not the shaft of the pump is spinning, and requires the COMMISS_LEVEL to be 1 or 2.

5.2.2 Pump

The pump action energizes the coils of a particular set of pumping units at the correct shaft angle for pumping, allowing the user to check that fluid is displaced by those pumping units. This can be used in conjunction with a flow meter or pressure sensor/gauge to verify the function of those pumping units.

COMMISS_ACT_TYPE_1 is 2 for the pump action, and the COMMISS_ACT_TYPE_2 parameter selects the coils to be fired (see Coil enabling section). A number of pumping strokes between 1 and 100 inclusive can be requested using COMMISS_VALUE_1.

The pump action is only available when the shaft is spinning and the minimum pumping speed is reached (see the ERR_AE_520975_17_LM_SHSPD error), and requires COMMISS_LEVEL to be 2.

5.2.3 Service configuration change

The service configuration change action allows the user to change the DDP096 service configuration to one of the pre-defined configurations.

COMMISS_ACT_TYPE_1 3 is for the service configuration change, and the COMMISS_VALUE_1 parameter sets the service configuration and updates the SERV_CONF_INDEX parameter with the new value, irrespective of the SERV_CONF_INDEX_SRC parameter source value (see the Service switching section).

The service configuration change action is always available, irrespective of the COMMISS_LEVEL.

5.2.4 Raw displacement

The raw displacement action allows the user to set a specific service of the DDP096 to pump indefinitely at a particular fraction of its available flow.

The COMMISS_VALUE_1 parameter sets the displacement fraction, and is scaled the same way as the DISP_REF_S1 parameter. Value 4 for COMMISS_ACT_TYPE_1 requests flow from service 1, value 5 for COMMISS_ACT_TYPE_1 requests flow from service 2 (in two-service and three-service DDP096 software), and value 6 for COMMISS_ACT_TYPE_1 requests flow from service 3 (in three-service DDP096 software). For two-service and three-service operation the selected service configuration is always that corresponding to the value of the SERV_CONF_INDEX parameter, irrespective of the SERV_CONF_INDEX_SRC parameter source (see the Service switching section). This can be changed in commissioning mode with the service configuration change action.

The raw displacement action is only available when the shaft is spinning and the minimum pumping speed is reached (see the ERR_AE_520975_17_LM_SHSPD error), and requires COMMISS_LEVEL to be 2.

5.2.5 Coil enabling

For fire or pump actions the user must enable a particular set of coils, encoded as a bitfield, to set the DPC12 coil outputs which are to be actuated. To enable a coil, the corresponding bit of the bitfield must be set.

The mapping between pumping unit, coil number and bit in the bitfield required to enable a particular pumping unit is shown in the following table.

Pumping unit	DPC12 output	COMMISS_ACT_TYPE_2 bitfield [11...0]
A1	Coil 01	xxxx xxxx xxx1
A2	Coil 04	xxxx xxxx xx1x
A3	Coil 07	xxxx xxxx x1xx
A4	Coil 10	xxxx xxxx 1xxx
B1	Coil 02	xxxx xxx1 xxxx
B2	Coil 05	xxxx xx1x xxxx
B3	Coil 08	xxxx x1xx xxxx
B4	Coil 11	xxxx 1xxx xxxx
C1	Coil 03	xxx1 xxxx xxxx
C2	Coil 06	xx1x xxxx xxxx
C3	Coil 09	x1xx xxxx xxxx
C4	Coil 12	1xxx xxxx xxxx

The bitfield is represented by an unsigned decimal integer in the COMMISS_ACT_TYPE_2 parameter. Examples of encoded bitfields are shown in the following table.

Bitfield	Integer	Meaning
0000 0000 0000	0	all disabled
0000 0000 0001	1	enable A1
0000 0000 0010	2	enable A2
0000 0000 0011	3	enable A1 and A2
0000 0001 0000	16	enable B1
0000 0001 0001	17	enable A1 and B1
1111 1111 1111	4095	all enabled

Please refer to the Digital Displacement® Pump Gen 1 DDP096 and DPC12 Technical Information for the physical locations of the pumping units within the DDP096 pump.

6 Control configuration

The DDP096 software is able to operate each service (hydraulic output) in multiple configurations to provide the required control response. Each service operates independently. These configurations are controlled by setting the value of the control mode, control reference source and limit source parameters (see Control mode parameters and Limits parameters sections). The application of these different options is detailed in the Digital Displacement® Pump Gen 1 DDP096 and DPC12 Technical Information. Please contact your Danfoss representative for further help with DDP096 control options.

The configuration must be set-up on each controller after delivery. As the DDP096 is a software-controlled product, the same software configuration will produce the same control response on all DDP096 and DPC12 hardware in a system with the same hydraulic circuit configuration. For series production systems it is recommended to setup the control configuration for the first product and export the parameter file using the PLUS+1® Service Tool. The same parameters can then be imported and downloaded to each subsequent DPC12 controller.

6.1 Use cases

From version 2.8.1 all available combinations of control mode, control reference source and limit source parameters may be selected in the software.

A subset of these combinations have been validated in testing by Danfoss to ensure the correct operation of all combinations. Please contact your Danfoss representative for further information on software validation testing.

6.2 Load-sense control mode

An external load-sense pressure sensor with a 4-20mA output is required for each service operating in load-sense mode. This sensor is connected on the load side of the orifice to provide pressure feedback to the DDP096 software. The DDP096 software must be configured to read the connected sensors correctly by setting the scale using the EXT_LS_SENS_SCALE_S1, EXT_LS_SENS_SCALE_S2, and EXT_LS_SENS_SCALE_S3 parameters. The parameter should be set by dividing the sensor's maximum valid pressure (the pressure for which it outputs 20 mA) by the range of valid currents (16 mA). For instance, a 600 bar sensor requires a scale factor of 37.5 mA/bar as

- `P max (bar) / I range (mA)`
- `600 bar / 16 mA`
- `37.5 bar/mA`

Please see the Digital Displacement® Pump Gen 1 DDP096 and DPC12 Technical Information for details of the electrical signal and connection requirements for the load-sense pressure sensor to operate with the DPC12 controller.

⚠ Warning

Incorrect setting of the external load-sense sensor scale will result in unregulated margin pressure in the service.

6.3 Example control configurations

6.3.1 Scenario 1 - single-service load-sense control with J1939 set-points

In this scenario, single-service software (AA) is used in a pressure-control load-sense system to maintain a particular margin. The margin is set by a system controller over CAN using J1939 messaging. A torque limit is also sent by the system controller using J1939 to limit the DDP096 pump's consumed torque.

1. Use the PLUS+1® Service Tool to set the control configuration
   - Set the CONTROL_MODE_S1 parameter to load-sense.
   - Set the CONTROL_REF_SRC_S1 parameter to J1939 to receive the load-sense pressure margin set-point from the system controller.
   - Set the TRQ_LIM_SRC_S1 parameter to J1939 to receive the torque limit from the system controller.
   - Set the PRESS_LIM_SRC_S1, FLOW_LIM_SRC_S1 and PWR_LIM_SRC_S1 parameters to unlimited to disable these limit functions.
   - Set the EXT_LS_SENS_SCALE_S1 parameter to match the installed load-sense pressure sensor.
   - Set the PRESS_REF_LIM_S1 parameter to the maximum desired outlet pressure. The pressure controller will not pump above this pressure, even if the target margin pressure is not met.
   - Set the PUMPING_ENABLE_SRC parameter to J1939 to receive the pumping enable signal from the system controller.
   - Set the SUPPORT_DM13_PGN parameter to enabled to prevent CAN bus timeout errors at start-up (see the Using the disabled state with DM13 section).
2. Send the required messages to the DPC12 controller from the system controller
   - Send the Pump setup A PGN with
     - all bits of the pumping enable field set to 0 (which will disable the pump).
     - the service configuration index field set to 255 (not used).
   - Send the Pressure margin reference A PGN with
     - the pressure margin reference for service 1 field set to the desired margin pressure.
     - the pressure margin reference for service 2 field set to 0xFFFF (not used).
     - the pressure margin reference for service 3 field set to 0xFFFF (not used).
   - Send the Torque limit A PGN with
     - the torque limit for service 1 field set to the desired torque limit.
     - the torque limit for service 2 field set to 0xFFFF (not used).
     - the torque limit for service 3 field set to 0xFFFF (not used).
3. Set up the optional status messages decoding
   - Decode the Pump info A PGN for pump status, including the DDP096 software's fault state via the device state field.
   - Decode the Service 1 status PGN for hydraulic output status, including the actual service pressure and actual service load-sense pressure.
   - Decode the DM1 PGN - active diagnostic trouble codes messages to record any active errors.
     - A multi-packet BAM session will be used to detail more than one active error.
4. Start the prime mover.
5. Check if the DDP096 software is in a fault or fault hold state (see Error handler states section) by either
   - Reading the DEVICE_STATE from the Pump info A message.
   - Decoding the Diagnostic LED.
6. Clear the fault state if required by
   - Sending the DM11 message (see the DM11 PGN - diagnostics data clear of active DTCs section).
   - Power-cycling the DPC12 controller. It is advised to stop the prime mover before power-cycling the controller.
7. Start the pump operation
   - Send the DM13 PGN to enter the active state.
   - Change the value of the pumping enable field in the Pump Setup A PGN to have a 1 in bit 0.
8. Ensure that the pump is generating flow to the system functions.
9. Monitor the status messages.

6.3.2 Scenario 2 - two-service displacement control with J1939 set-points and dynamic ganging

In this scenario, two-service software (AB) is used in displacement control to deliver flow to two services with the pumping units assigned to each service varying (see Service switching section). The displacement fraction for each service (relative to the volume of pumping units assigned to the service) is set by a system controller over CAN using J1939 messaging. The service configuration is also set by the system controller using J1939 to dynamically allocate pumplets to each service. A static flow limit is set for one service to limit the available flow. The system controller must also control the external hydraulic ganging valves to match the configuration sent to the DDP096 controller.

1. Use the PLUS+1® Service Tool to set the control configuration
   - Set the CONTROL_MODE_S1 and CONTROL_MODE_S2 parameters to displacement control.
   - Set the CONTROL_REF_SRC_S1 and CONTROL_REF_SRC_S2 parameters to J1939 to receive the displacement reference from the system controller.
   - Set the FLOW_LIM_SRC_S1 parameter to PLUS+1 to use a static flow limit on service 1.
   - Set the FLOW_LIM_S1 parameter to the required flow limit for service 1.
   - Set the PRESS_LIM_SRC_S1, TRQ_LIM_SRC_S1 and PWR_LIM_SRC_S1 parameters to unlimited to disable these limit functions for service 1.
   - Set the PRESS_LIM_SRC_S2, FLOW_LIM_SRC_S2, TRQ_LIM_SRC_S2 and PWR_LIM_SRC_S2 parameters to unlimited to disable these limit functions for service 2.
   - Set the PUMPING_ENABLE_SRC parameter to J1939 to receive the pumping enable signal from the system controller.
   - Set the SUPPORT_DM13_PGN parameter to enabled to prevent CAN bus timeout errors at start-up (see the Using the disabled state with DM13 section).
2. Send the required messages to the DPC12 controller from the system controller
   - Send the Pump setup A PGN with
     - all bits of the pumping enable field set to 0 (which will disable the pump).
     - the service configuration index field set to 1 (service 1 is pumplets 1+3, service 2 is pumplet 4).
   - Send the Displacement reference A PGN with
     - the displacement reference for service 1 field set to the desired starting displacement.
     - the displacement reference for service 2 field set to the desired starting displacement.
     - the displacement reference for service 3 field set to 0xFFFF (not used).
3. Set up the optional status messages decoding
   - Decode the Pump info A PGN for pump status, including the DDP096 software's fault state via the device state field.
   - Decode the Service 1 status PGN for hydraulic output status for service 1, including the actual service pressure and actual service displacement.
   - Decode the Service 2 status PGN for hydraulic output status for service 2, including the actual service pressure and actual service displacement.
   - Decode the DM1 PGN - active diagnostic trouble codes messages to record any active errors.
     - A multi-packet BAM session will be used to detail more than one active error.
4. Set the external hydraulic ganging valves to match the service switching configuration.
5. Start the prime mover.
6. Check if the DDP096 software is in a fault or fault hold state (see Error handler states section) by either
   - Reading the DEVICE_STATE from the Pump info A message.
   - Decoding the Diagnostic LED.
7. Clear the fault state if required by
   - Sending the DM11 message (see the DM11 PGN - diagnostics data clear of active DTCs section).
   - Power-cycling the DPC12 controller. It is advised to stop the prime mover before power-cycling the controller.
8. Start the pump operation
   - Send the DM13 PGN to enter the active state.
   - Change the value of the pumping enable field in the Pump Setup A PGN to have a 1 in bits 0 and 1.
9. Ensure that the pump is generating flow to the system functions on both services.
10. Change the displacement references and service configuration sent over CAN as required to maintain the desired pump response.
11. Monitor the status messages.

7 Multi-service operation

Two- and three-service DDP096 software is available for use with a DDP096 pump fitted with a multi-outlet endcap. These software variants allow a single pump and controller to provide flow to two or three hydraulic circuits simultaneously. See the Software variants section for further details. The parameters for service 1 (marked _S1), service 2 (marked _S2) and service 3 (in a three-service build, marked _S3) must be configured suitably for the hydraulic system or vehicle.

7.1 Service independence

Each service controlled by the DDP096 software acts as an independent flow source.

Any coordination between the services, for instance a whole-pump torque limit, must be calculated by a system controller and communicated to the pump as a control reference or limit per service.

7.2 Service switching

Service switching, also known as dynamic ganging, allows the allocation of some of the pumping units of the pump to be switched from one control service to another under the command of a system controller. The DPC12 controller does not control the external valves or other hydraulic equipment needed to connect the correct outlet ports of the DDP096 pump. This must be considered in the system controller design.

⚠ Warning

The physical hydraulic connections of the relevant output ports of the DDP096 pump must match the service configuration selected. Mismatch could result in unintended flow to a particular service.

In this release, service switching is available in the two-service software variant only. In a future release more flexible service switching will be available for all multi-service software variants.

The twelve pumping units in the machine are grouped into four independent groups, each consisting of three interconnected pumping units. These groups are known as "pumplets". An example of how the pumplets, pumping units and outlet ports relate is shown below. Please refer to the Digital Displacement® Pump Gen 1 DDP096 and DPC12 Technical Information for further information.

Pumplet	Pumping units	Outlet port (three-outlet endcap)
1+3	A1, A3, B1, B3, C1, C3	P1
2	A2, B2, C2	P2
4	A4, B4, C4	P4

The service switching feature is controlled by supplying a configuration index (SERV_CONF_INDEX) to select the active combination of pumplets assigned to the service. This index can be set statically in the PLUS+1® Service Tool or commanded dynamically by a system controller over J1939. The following table describes the pumplet-to-service assignment for each available configuration:

Index	Service 1	Service 2	Notes
0	1+3	2, 4	
1	1+3	4	There is no flow from pumplet 2
2	1+3, 2	4	

The service configuration can be changed while the pump is in operation. When commanding a service, the flow, torque and power limit signals always relate to the real hydraulic output of the service. The displacement reference is a fraction of the displacement available from the pumping units currently assigned to a service; the available displacement may change as the service configuration is changed.

⚠ Warning

There will be a change in flow for a given displacement reference command when the service configuration is changed under displacement control.

8 Parameters

The DDP096 is a software-driven product, and many parameters are available to configure the software to the user's requirements. These parameters are accessed using the Danfoss PLUS+1® Service Tool. This section provides a list of all available parameters with a description of their effect. Default, maximum and minimum valid values are also detailed in raw (unscaled) units.

The parameter interface uses integer types, and therefore the correct scaling must be applied to interpret the data for fractional values.

8.1 Communication parameters

The DDP096 software on the DPC12 can be configured, controlled and monitored over its CAN bus connection using two protocols, the Danfoss PLUS+1® Service Tool interface and the SAE J1939 standard.

These parameters set up the configuration required to communicate with the DPC12 over these interfaces.

Name (read, write)	Description	Service Tool Parameter Name	Limit Min	Limit Max	Default Value	Notes
Baud Rate (R/W)	CAN bus baud rate in kilobaud.	BAUD_RATE	125	1000	250	Valid values: 125, 250, 500, 1000
Node address (R/W)	Node address of controller. Recommended address range is 208-223	NODE_ID	0	238	208	Boot node address (PLUS+1®) = App Node address (J1939)
Function and ECU Instance (R/W)	Function and ECU instance for J1939 NAME. Bit [2:0] ECU instance value for NAME (0 to 7). Bit [7:3] Function instance value for NAME (0 to 31).	FUN_ECU_INSTANCE	0	255	0	
Ignore Error Passive Flag (R/W)	When enabled, the controller will ignore a "CAN error passive flag" error from the CAN interface. If the controller is used in a system without a CAN bus, this parameter should be enabled to allow pumping.	IGNORE_EPV_FLAG	0	1	0	0 - disabled, 1 - enabled
Support DM13 PGN (R/W)	When enabled, the controller ignores all warning and info severity errors and the pump is not allowed to produce flow until the "Start Diagnostic DM13" CAN message is received. See Using the disabled state with DM13 section.	SUPPORT_DM13_PGN	0	1	1	0 - disabled, 1 - enabled
Reset Error Counter Command (R/W)	Resets error counters to zero. Each time the command is issued, up to 29 error counters are reset. Issue command three times to ensure all error counters are reset.	RESET_ERR_CNTR_CMD	0	1	0	0- off, 1- start

8.2 Pump setting parameters

These parameters control hydraulic output features which are common to all of the services of the pump.

Name (read, write)	Description	Service Tool Parameter Name	Limit Min	Limit Max	Default Value	Notes
External Load-sense Sensor Scale Service 1 (R/W)	The scale factor for the external load-sense sensor attached to the controller, if used.	EXT_LS_SENS_SCALE_S1	625	6250	3750	in 0.01 bar/mA
External Load-sense Sensor Scale Service 2 (R/W)	The scale factor for the external load-sense sensor attached to the controller, if used.	EXT_LS_SENS_SCALE_S2	625	6250	3750	in 0.01 bar/mA
External Load-sense Sensor Scale Service 3 (R/W)	The scale factor for the external load-sense sensor attached to the controller, if used.	EXT_LS_SENS_SCALE_S3	625	6250	3750	in 0.01 bar/mA
Pressure Error Limit (R/W)	The pressure at which the "Pressure Too High Error" will be triggered.	PRESS_ERROR_LIM	50	500	500	in bar
Shaft speed low Limit (R/W)	Pump shaft speed below which the pump will not produce flow. Shaft speed below limit error will be active below this speed.	SHAFT_SPD_LOW_LIM	300	3000	300	in rpm
Pumping Enable Source (R/W)	The source for the pumping enable signal.	PUMPING_ENABLE_SRC	1	2	1	1- PLUS+1®, 2- J1939
Pumping Enable (R/W)	Enables pumping of each service individually.	PUMPING_ENABLE	0	255	0	Service 1 by bit 0, Service 2 by bit 1, Service 3 by bit 2. Set other bits to 0.

Name (read, write)	Description	Service Tool Parameter Name	Limit Min	Limit Max	Default Value	Notes
Service Configuration Index Source (R/W)	The source for the service configuration selection index.	SERV_CONF_INDEX_SRC	1	2	1	1- PLUS+1®, 2- J1939
Service Configuration Index (R/W)	Selects the service configuration, assigning particular pumplets to a service, from the pre-configured options.	SERV_CONF_INDEX	0	2	0	Refer to the Service switching section for more details.

8.3 Pump and controller status parameters

These parameters report status information which relates to the controller or entire pump.

Name (read, write)	Description	Service Tool Parameter Name	Limit Min	Limit Max	Default Value	Notes
Device Mode (R)	Current mode of controller.	DEVICE_MODE	0	2	0	0- Normal, 1- Limp, 2- Commissioning
Device State (R)	Current state of controller when in Normal Mode.	DEVICE_STATE	0	4	0	0 - Initialization, 1 - Disabled, 2 - Active, 3 - Error, 4 - Error Hold
Actual Shaft Speed (R)	Current value of shaft speed read from pump shaft speed/temperature sensor. Positive direction is clockwise when looking at the end of the input shaft.	ACTL_SHAFT_SPD	-3500	3500	0	in rpm
Actual Pump Temperature (R)	Current value of pump temperature read from pump shaft speed/temperature sensor.	ACTL_PUMP_TEMP	-40	150	0	in °C
FPGA Revision Main (R)	Build revision of the firmware running on the main controller's internal FPGA.	FPGA_REVISION_MAIN	0	10^6	0	

8.4 Service 1 parameters

These parameters control hydraulic output features which are specific to Service 1 of the pump. See Control configuration section for more details.

8.4.1 Control mode parameters

These parameters select the control mode of the pump and the source of the reference for the selected control mode.

Name (read, write)	Description	Service Tool Parameter Name	Limit Min	Limit Max	Default Value	Notes
Control Mode Service 1 (R/W)	Sets the mode by which the service outlet flow is controlled.	CONTROL_MODE_S1	0	2	0	0- Displacement control, 1- Pressure control, 2- Load-sense
Control Reference Source Service 1 (R/W)	Interface to set the reference input to the selected control mode.	CONTROL_REF_SRC_S1	1	2	1	1- PLUS+1®, 2- J1939

8.4.2 Control reference parameters

These parameters represent the reference values which are used in the current control mode.

Only the parameter for the currently selected control mode is used by the software.

The parameter operates differently depending on the reference source selected. With the source set to PLUS+1®, the value is set using this parameter. With the source set to J1939, the value becomes read-only and shows the last value received by the controller.

Name (read, write)	Description	Service Tool Parameter Name	Limit Min	Limit Max	Default Value	Notes
Displacement Reference Service 1 (R/W)	The target displacement the pump should try to produce on this service as a fraction of the available displacement.	DISP_REF_S1	0	10000	0	in 0.01 %

Name (read, write)	Description	Service Tool Parameter Name	Limit Min	Limit Max	Default Value	Notes
Pressure Reference Service 1 (R/W)	The target pressure for the pump to maintain at its outlet when in pressure control mode.	PRESS_REF_S1	0	420	0	in bar
Pressure Margin Reference Service 1 (R/W)	The target margin pressure for the pump to maintain between its outlet and the external load-sense pressure sensor when in load-sense control mode.	PRESS_MARGIN_REF_S1	0	100	0	in bar

8.4.3 Limits parameters

The limits available are applied to the displacement demand from the selected control mode. Each limit is applied such that the output of the service will be restricted to the lowest limit supplied. Each limit can be supplied by either J1939 or PLUS+1®.

Each limit parameter operates differently depending on the reference source selected. With the source set to PLUS+1®, the value is set using the limit parameter. With the source set to J1939, the value becomes read-only and the limit parameter shows the last value received by the controller.

Name (read, write)	Description	Service Tool Parameter Name	Limit Min	Limit Max	Default Value	Notes
Pressure Limit Source Service 1 (R/W)	The limit value source for the service pressure limiting feature.	PRESS_LIM_SRC_S1	0	1	0	0- Unlimited, 1- PLUS+1®
Pressure Low Limit Service 1 (R/W)	The pressure at which the displacement limit for pressure equals 100%. The displacement limit for pressure decreases linearly between Pressure Low Limit and Pressure High Limit as pressure increases.	PRESS_LOW_LIM_S1	0	420	0	in bar
Pressure High Limit Service 1 (R/W)	The pressure at which the displacement limit for pressure equals 0%. The displacement limit for pressure decreases linearly between Pressure Low Limit and Pressure High Limit as pressure increases.	PRESS_HIGH_LIM_S1	0	450	0	in bar
Flow Limit Source Service 1 (R/W)	The limit value source for the service flow limiting feature.	FLOW_LIM_SRC_S1	0	2	0	0- Unlimited, 1- PLUS+1®, 2- J1939
Flow Limit Service 1 (R/W)	The maximum allowed flow in terms of theoretical displacement of the pump, which does not account for oil compressibility and pump shrinkage. The pump will adjust the service displacement according to the shaft speed in order to stay below this limit.	FLOW_LIM_S1	0	300	0	in L/min
Torque Limit Source Service 1 (R/W)	The limit value source for the service torque limiting feature.	TRQ_LIM_SRC_S1	0	2	0	0- Unlimited, 1- PLUS+1®, 2- J1939
Torque Limit Service 1 (R/W)	The maximum torque allowed to be applied by the service. The pump will adjust the service displacement according to the outlet pressure in order to stay below this limit.	TRQ_LIM_S1	0	1500	0	in Nm
Power Limit Source Service 1 (R/W)	The limit value source for the service power limiting feature.	PWR_LIM_SRC_S1	0	2	0	0- Unlimited, 1- PLUS+1®, 2- J1939
Power Limit Service 1 (R/W)	The maximum power allowed to be consumed by the service. The pump will adjust the service displacement according to the outlet pressure and shaft speed in order to stay below this limit.	PWR_LIM_S1	0	500	0	in kW
Start Up Ramp Time Service 1 (R/W)	The start-up ramp limits the available displacement after reaching the minimum allowed speed for pumping or enabling the service for a set time. This parameter sets the time over which this limit increases from 0% to 100%. The output displacement set by the current control mode and references will be restricted to this limit during this time. For further details see the Digital Displacement® Pump Gen 1 DDP096 and DPC12 Technical Information.	START_UP_RAMP_TIME_S1	0	100	0	in 0.1 seconds. Set to 0 to disable ramp.

8.4.4 Control loop gain parameters

These parameters allow the user to tune the pressure control loop proportional-integrator (PI) gains to give the pump the best pressure response in their particular system. The gains are used in both pressure control and load-sense control modes.

The read-only parameters in the service status section allow various parts of the PI loop to be inspected while the pump is running.

Name (read, write)	Description	Service Tool Parameter Name	Limit Min	Limit Max	Default Value	Notes
Pressure Reference Limit Service 1 (R/W)	Limits maximum value of Actual Reference Pressure, the pressure the pump tries to maintain on its outlet in pressure control or load-sense control modes.	PRESS_REF_LIM_S1	0	420	0	in bar
Pressure Small Gain Service 1 (R/W)	The small proportional gain in the pressure control loop.	PRESS_SMALL_GAIN_S1	0	10000	0	in 0.001 %/bar
Pressure Small Gain Threshold Service 1 (R/W)	The minimum pressure error needed for the small gain to take effect.	PRESS_SMALL_GAIN_THRESH_S1	0	600	0	in bar
Pressure Gain Big Gain Service 1 (R/W)	The big proportional gain in the pressure control loop.	PRESS_BIG_GAIN_S1	0	50000	0	in 0.001 %/bar
Pressure Big Gain Threshold Service 1 (R/W)	The minimum pressure error needed for the big gain to take effect.	PRESS_BIG_GAIN_THRESH_S1	0	600	600	in bar
Pressure Integration Time Service 1 (R/W)	The integration time for the integrator in the pressure control loop.	PRESS_INTEG_TIME_S1	0	10000	0	in ms
Pressure Integration Max Disp Service 1 (R/W)	The maximum displacement of the integrator in the pressure control loop.	PRESS_INTEG_MAX_DISP_S1	0	10000	10000	in 0.01 %
Pressure Integration Min Disp Service 1 (R/W)	The minimum displacement of the integrator in the pressure control loop.	PRESS_INTEG_MIN_DISP_S1	-10000	0	0	in 0.01 %

8.4.5 Service status parameters

These parameters report the current values produced by the software's control loop and the hydraulic output of the service.

Name (read, write)	Description	Service Tool Parameter Name	Limit Min	Limit Max	Default Value	Notes
Actual Displacement Service 1 (R)	Current value of displacement after all limits have been applied.	ACTL_DISP_S1	0	10000	0	in 0.01%
Actual Pressure Reference Service 1 (R)	Current value of pressure used for the pressure control loop after pressure margin reference (load-sense control only) and pressure reference limit are applied.	ACTL_PRESS_REF_S1	0	600	0	in bar
Actual Pressure Service 1 (R)	The current pressure read from the outlet pressure sensor.	ACTL_PRESS_S1	0	600	0	in bar
Actual Pressure Margin Reference Service 1 (R)	Current value of margin pressure setpoint for used in the control loop.	ACTL_PRESS_MARGIN_REF_S1	0	100	0	in bar
Actual Load Sensing Pressure Service 1 (R)	The current pressure read from the external load sense pressure sensor in load-sense control mode.	ACTL_LS_PRESS_S1	0	1000	0	in bar
Actual Small Gain Displacement Service 1 (R)	Current value of displacement commanded by the small gain portion of the pressure control loop.	ACTL_SMALL_GAIN_DISP_S1	-10^9	10^9	0	in 0.01%
Actual Big Gain Displacement Service 1 (R)	Current value of displacement commanded by the big gain portion of the pressure control loop.	ACTL_BIG_GAIN_DISP_S1	-10^9	10^9	0	in 0.01%
Actual Integrator Displacement Service 1 (R)	Current value of displacement commanded by the integrator portion of the pressure control loop.	ACTL_INTEG_DISP_S1	-10000	10000	0	in 0.01%
Actual Pressure Control Loop Displacement Service 1 (R)	Current value of displacement commanded by the pressure control loop before limiting.	ACTL_PRESS_CTRL_LOOP_DISP_S1	0	10000	0	in 0.01%

8.5 Service 2 parameters

The Service 2 parameters are used to control Service 2 in two-service and three-service software. The function of each is the same as the corresponding Service 1 parameter — refer to the Service 1 parameters section further descriptions. When using single-service software the Service 2 parameters have no effect and may be removed from single-service software in a future release.

8.5.1 Control mode parameters

Name (read, write)	Description	Service Tool Parameter Name	Limit Min	Limit Max	Default Value	Notes
Control Mode Service 2 (R/W)	Sets the mode by which the service outlet flow is controlled.	CONTROL_MODE_S2	0	2	0	0- Displacement control, 1- Pressure control, 2- Load-sense
Control Reference Source Service 2 (R/W)	Interface to set the reference input to the selected control mode.	CONTROL_REF_SRC_S2	1	2	1	1- PLUS+1®, 2- J1939

8.5.2 Control reference parameters

Name (read, write)	Description	Service Tool Parameter Name	Limit Min	Limit Max	Default Value	Notes
Displacement Reference Service 2 (R/W)	The target displacement the pump should try to produce on this service as a fraction of the available displacement.	DISP_REF_S2	0	10000	0	in 0.01 %
Pressure Reference Service 2 (R/W)	The target pressure for the pump to maintain at its outlet when in pressure control mode.	PRESS_REF_S2	0	420	0	in bar
Pressure Margin Reference Service 2 (R/W)	The target margin pressure for the pump to maintain between its outlet and the external load-sense pressure sensor when in load-sense control mode.	PRESS_MARGIN_REF_S2	0	100	0	in bar

8.5.3 Limits parameters

Name (read, write)	Description	Service Tool Parameter Name	Limit Min	Limit Max	Default Value	Notes
Pressure Limit Source Service 2 (R/W)	The limit value source for the service pressure limiting feature.	PRESS_LIM_SRC_S2	0	1	0	0- Unlimited, 1- PLUS+1®
Pressure Low Limit Service 2 (R/W)	The pressure at which the displacement limit for pressure equals 100%. The displacement limit for pressure decreases linearly between Pressure Low Limit and Pressure High Limit as pressure increases.	PRESS_LOW_LIM_S2	0	420	0	in bar
Pressure High Limit Service 2 (R/W)	The pressure at which the displacement limit for pressure equals 0%. The displacement limit for pressure decreases linearly between Pressure Low Limit and Pressure High Limit as pressure increases.	PRESS_HIGH_LIM_S2	0	450	0	in bar
Flow Limit Source Service 2 (R/W)	The limit value source for the service flow limiting feature.	FLOW_LIM_SRC_S2	0	2	0	0- Unlimited, 1- PLUS+1®, 2- J1939
Flow Limit Service 2 (R/W)	The maximum allowed flow in terms of theoretical displacement of the pump, which does not account for oil compressibility and pump shrinkage. The pump will adjust the service displacement according to the shaft speed in order to stay below this limit.	FLOW_LIM_S2	0	300	0	in L/min
Torque Limit Source Service 2 (R/W)	The limit value source for the service torque limiting feature.	TRQ_LIM_SRC_S2	0	2	0	0- Unlimited, 1- PLUS+1®, 2- J1939
Torque Limit Service 2 (R/W)	The maximum torque allowed to be applied by the service. The pump will adjust the service displacement according to the outlet pressure in order to stay below this limit.	TRQ_LIM_S2	0	1500	0	in Nm
Power Limit Source Service 2 (R/W)	The limit value source for the service power limiting feature.	PWR_LIM_SRC_S2	0	2	0	0- Unlimited, 1- PLUS+1®, 2- J1939
Power Limit Service 2 (R/W)	The maximum power allowed to be consumed by the service. The pump will adjust the service displacement according to the outlet pressure and shaft speed in order to stay below this limit.	PWR_LIM_S2	0	500	0	in kW

Name (read, write)	Description	Service Tool Parameter Name	Limit Min	Limit Max	Default Value	Notes
Start Up Ramp Time Service 2 (R/W)	The start-up ramp limits the available displacement after reaching the minimum allowed speed for pumping or enabling the service for a set time. This parameter sets the time over which this limit increases from 0% to 100%. The output displacement set by the current control mode and references will be restricted to this limit during this time. For further details see the Digital Displacement® Pump Gen 1 DDP096 and DPC12 Technical Information.	START_UP_RAMP_TIME_S2	0	100	0	in 0.1 seconds. Set to 0 to disable ramp.

8.5.4 Control loop gain parameters

Name (read, write)	Description	Service Tool Parameter Name	Limit Min	Limit Max	Default Value	Notes
Pressure Reference Limit Service 2 (R/W)	Limits maximum value of Actual Reference Pressure, the pressure the pump tries to maintain on its outlet in pressure control or load-sense control modes.	PRESS_REF_LIM_S2	0	420	0	in bar
Pressure Small Gain Service 2 (R/W)	The small proportional gain in the pressure control loop.	PRESS_SMALL_GAIN_S2	0	10000	0	in 0.001 %/bar
Pressure Small Gain Threshold Service 2 (R/W)	The minimum pressure error needed for the small gain to take effect.	PRESS_SMALL_GAIN_THRESH_S2	0	600	0	in bar
Pressure Gain Big Gain Service 2 (R/W)	The big proportional gain in the pressure control loop.	PRESS_BIG_GAIN_S2	0	50000	0	in 0.001 %/bar
Pressure Big Gain Threshold Service 2 (R/W)	The minimum pressure error needed for the big gain to take effect.	PRESS_BIG_GAIN_THRESH_S2	0	600	600	in bar
Pressure Integration Time Service 2 (R/W)	The integration time for the integrator in the pressure control loop.	PRESS_INTEG_TIME_S2	0	10000	0	in ms
Pressure Integration Max Disp Service 2 (R/W)	The maximum displacement of the integrator in the pressure control loop.	PRESS_INTEG_MAX_DISP_S2	0	10000	10000	in 0.01 %
Pressure Integration Min Disp Service 2 (R/W)	The minimum displacement of the integrator in the pressure control loop.	PRESS_INTEG_MIN_DISP_S2	-10000	0	0	in 0.01 %

8.5.5 Service status parameters

Name (read, write)	Description	Service Tool Parameter Name	Limit Min	Limit Max	Default Value	Notes
Actual Displacement Service 2 (R)	Current value of displacement after all limits have been applied.	ACTL_DISP_S2	0	10000	0	in 0.01%
Actual Pressure Reference Service 2 (R)	Current value of pressure used for the pressure control loop after pressure margin reference (load-sense control only) and pressure reference limit are applied.	ACTL_PRESS_REF_S2	0	600	0	in bar
Actual Pressure Service 2 (R)	The current pressure read from the outlet pressure sensor.	ACTL_PRESS_S2	0	600	0	in bar
Actual Pressure Margin Reference Service 2 (R)	Current value of margin pressure setpoint for used in the control loop.	ACTL_PRESS_MARGIN_REF_S2	0	100	0	in bar
Actual Load Sensing Pressure Service 2 (R)	The current pressure read from the external load sense pressure sensor in load-sense control mode.	ACTL_LS_PRESS_S2	0	1000	0	in bar
Actual Small Gain Displacement Service 2 (R)	Current value of displacement commanded by the small gain portion of the pressure control loop.	ACTL_SMALL_GAIN_DISP_S2	-10^9	10^9	0	in 0.01%
Actual Big Gain Displacement Service 2 (R)	Current value of displacement commanded by the big gain portion of the pressure control loop.	ACTL_BIG_GAIN_DISP_S2	-10^9	10^9	0	in 0.01%
Actual Integrator Displacement Service 2 (R)	Current value of displacement commanded by the integrator portion of the pressure control loop.	ACTL_INTEG_DISP_S2	-10000	10000	0	in 0.01%
Actual Pressure Control Loop Displacement Service 2 (R)	Current value of displacement commanded by the pressure control loop before limiting.	ACTL_PRESS_CTRL_LOOP_DISP_S2	0	10000	0	in 0.01%

8.6 Service 3 parameters

The Service 3 parameters are used to control Service 3 in three-service software. The function of each is the same as the corresponding Service 1 parameter — refer to the Service 1 parameters section further descriptions. When using single-service or two-service software the Service 3 parameters have no effect and may be removed from these software builds in a future release.

8.6.1 Control mode parameters

Name (read, write)	Description	Service Tool Parameter Name	Limit Min	Limit Max	Default Value	Notes
Control Mode Service 3 (R/W)	Sets the mode by which the service outlet flow is controlled.	CONTROL_MODE_S3	0	2	0	0- Displacement control, 1- Pressure control, 2- Load-sense
Control Reference Source Service 3 (R/W)	Interface to set the reference input to the selected control mode.	CONTROL_REF_SRC_S3	1	2	1	1- PLUS+1®, 2- J1939

8.6.2 Control reference parameters

Name (read, write)	Description	Service Tool Parameter Name	Limit Min	Limit Max	Default Value	Notes
Displacement Reference Service 3 (R/W)	The target displacement the pump should try to produce on this service as a fraction of the available displacement.	DISP_REF_S3	0	10000	0	in 0.01 %
Pressure Reference Service 3 (R/W)	The target pressure for the pump to maintain at its outlet when in pressure control mode.	PRESS_REF_S3	0	420	0	in bar
Pressure Margin Reference Service 3 (R/W)	The target margin pressure for the pump to maintain between its outlet and the external load-sense pressure sensor when in load-sense control mode.	PRESS_MARGIN_REF_S3	0	100	0	in bar

8.6.3 Limits parameters

Name (read, write)	Description	Service Tool Parameter Name	Limit Min	Limit Max	Default Value	Notes
Pressure Limit Source Service 3 (R/W)	The limit value source for the service pressure limiting feature.	PRESS_LIM_SRC_S3	0	1	0	0- Unlimited, 1- PLUS+1®
Pressure Low Limit Service 3 (R/W)	The pressure at which the displacement limit for pressure equals 100%. The displacement limit for pressure decreases linearly between Pressure Low Limit and Pressure High Limit as pressure increases.	PRESS_LOW_LIM_S3	0	420	0	in bar
Pressure High Limit Service 3 (R/W)	The pressure at which the displacement limit for pressure equals 0%. The displacement limit for pressure decreases linearly between Pressure Low Limit and Pressure High Limit as pressure increases.	PRESS_HIGH_LIM_S3	0	450	0	in bar
Flow Limit Source Service 3 (R/W)	The limit value source for the service flow limiting feature.	FLOW_LIM_SRC_S3	0	2	0	0- Unlimited, 1- PLUS+1®, 2- J1939
Flow Limit Service 3 (R/W)	The maximum allowed flow in terms of theoretical displacement of the pump, which does not account for oil compressibility and pump shrinkage. The pump will adjust the service displacement according to the shaft speed in order to stay below this limit.	FLOW_LIM_S3	0	300	0	in L/min
Torque Limit Source Service 3 (R/W)	The limit value source for the service torque limiting feature.	TRQ_LIM_SRC_S3	0	2	0	0- Unlimited, 1- PLUS+1®, 2- J1939
Torque Limit Service 3 (R/W)	The maximum torque allowed to be applied by the service. The pump will adjust the service displacement according to the outlet pressure in order to stay below this limit.	TRQ_LIM_S3	0	1500	0	in Nm
Power Limit Source Service 3 (R/W)	The limit value source for the service power limiting feature.	PWR_LIM_SRC_S3	0	2	0	0- Unlimited, 1- PLUS+1®, 2- J1939
Power Limit Service 3 (R/W)	The maximum power allowed to be consumed by the service. The pump will adjust the service displacement according to the outlet pressure and shaft speed in order to stay below this limit.	PWR_LIM_S3	0	500	0	in kW

Name (read, write)	Description	Service Tool Parameter Name	Limit Min	Limit Max	Default Value	Notes
Start Up Ramp Time Service 3 (R/W)	The start-up ramp limits the available displacement after reaching the minimum allowed speed for pumping or enabling the service for a set time. This parameter sets the time over which this limit increases from 0% to 100%. The output displacement set by the current control mode and references will be restricted to this limit during this time. For further details see the Digital Displacement® Pump Gen 1 DDP096 and DPC12 Technical Information.	START_UP_RAMP_TIME_S3	0	100	0	in 0.1 seconds. Set to 0 to disable ramp.

8.6.4 Control loop gain parameters

Name (read, write)	Description	Service Tool Parameter Name	Limit Min	Limit Max	Default Value	Notes
Pressure Reference Limit Service 3 (R/W)	Limits maximum value of Actual Reference Pressure, the pressure the pump tries to maintain on its outlet in pressure control or load-sense control modes.	PRESS_REF_LIM_S3	0	420	0	in bar
Pressure Small Gain Service 3 (R/W)	The small proportional gain in the pressure control loop.	PRESS_SMALL_GAIN_S3	0	10000	0	in 0.001 %/bar
Pressure Small Gain Threshold Service 3 (R/W)	The minimum pressure error needed for the small gain to take effect.	PRESS_SMALL_GAIN_THRESH_S3	0	600	0	in bar
Pressure Gain Big Gain Service 3 (R/W)	The big proportional gain in the pressure control loop.	PRESS_BIG_GAIN_S3	0	50000	0	in 0.001 %/bar
Pressure Big Gain Threshold Service 3 (R/W)	The minimum pressure error needed for the big gain to take effect.	PRESS_BIG_GAIN_THRESH_S3	0	600	600	in bar
Pressure Integration Time Service 3 (R/W)	The integration time for the integrator in the pressure control loop.	PRESS_INTEG_TIME_S3	0	10000	0	in ms
Pressure Integration Max Disp Service 3 (R/W)	The maximum displacement of the integrator in the pressure control loop.	PRESS_INTEG_MAX_DISP_S3	0	10000	10000	in 0.01 %
Pressure Integration Min Disp Service 3 (R/W)	The minimum displacement of the integrator in the pressure control loop.	PRESS_INTEG_MIN_DISP_S3	-10000	0	0	in 0.01 %

8.6.5 Service status parameters

Name (read, write)	Description	Service Tool Parameter Name	Limit Min	Limit Max	Default Value	Notes
Actual Displacement Service 3 (R)	Current value of displacement after all limits have been applied.	ACTL_DISP_S3	0	10000	0	in 0.01%
Actual Pressure Reference Service 3 (R)	Current value of pressure used for the pressure control loop after pressure margin reference (load-sense control only) and pressure reference limit are applied.	ACTL_PRESS_REF_S3	0	600	0	in bar
Actual Pressure Service 3 (R)	The current pressure read from the outlet pressure sensor.	ACTL_PRESS_S3	0	600	0	in bar
Actual Pressure Margin Reference Service 3 (R)	Current value of margin pressure setpoint for used in the control loop.	ACTL_PRESS_MARGIN_REF_S3	0	100	0	in bar
Actual Load Sensing Pressure Service 3 (R)	The current pressure read from the external load sense pressure sensor in load-sense control mode.	ACTL_LS_PRESS_S3	0	1000	0	in bar
Actual Small Gain Displacement Service 3 (R)	Current value of displacement commanded by the small gain portion of the pressure control loop.	ACTL_SMALL_GAIN_DISP_S3	-10^9	10^9	0	in 0.01%
Actual Big Gain Displacement Service 3 (R)	Current value of displacement commanded by the big gain portion of the pressure control loop.	ACTL_BIG_GAIN_DISP_S3	-10^9	10^9	0	in 0.01%
Actual Integrator Displacement Service 3 (R)	Current value of displacement commanded by the integrator portion of the pressure control loop.	ACTL_INTEG_DISP_S3	-10000	10000	0	in 0.01%
Actual Pressure Control Loop Displacement Service 3 (R)	Current value of displacement commanded by the pressure control loop before limiting.	ACTL_PRESS_CTRL_LOOP_DISP_S3	0	10000	0	in 0.01%

8.7 Other parameters

Name (read, write)	Description	Service Tool Parameter Name	Limit Min	Limit Max	Default Value	Notes
Suppress Power Supply below limit error when Shaft speed below low limit (R/W)	When enabled, the Power Supply Below Limit error will not be triggered when the shaft speed is below its low limit. Useful during engine cranking when the power supply voltage may be low and Support DM13 PGN is disabled.	SUPPRESS_PWR_SUPPLY_ERR_BLW_LOW_SPD	0	1	0	0 - disabled, 1 - enabled
Shaft Max Smoothing Count (R/W)	Used to interpret the speed sensor signal. Danfoss recommends using the default value. If tuning is required, contact Danfoss.	SHAFT_SPD_SMTH_COUNT	0	100	13	Number of shaft sensor edges
Shaft Max Smoothing Period (R/W)	Used to interpret the speed sensor signal. Danfoss recommends using the default value. If tuning is required, contact Danfoss.	SHAFT_SPD_SMTH_PERIOD	0	32767	32767	x 0.02 ms
Shaft Max Smoothing Angle (R/W)	Used to interpret the speed sensor signal. Danfoss recommends using the default value. If tuning is required, contact Danfoss.	SHAFT_SPD_SMTH_ANGLE	0	7200	7200	x 0.1 degrees
Enable Manual Solenoid Test (R/W)	Causes the DPC12 to perform a user-initiated test on the electrical characteristics of the low pressure valve solenoids to determine if they are present and to detect wiring faults.	EN_MANUAL_SOLENOID_FAULT_TEST	0	1	0	0 - disabled, 1 - manual trigger
Enable Startup Solenoid Test (R/W)	Sets the controller to automatically perform a test at startup on the electrical characteristics of the low pressure valve solenoids to determine if they are present and to detect wiring faults. In order to protect the output electronics, this diagnostic test runs before any solenoids are used normally.	EN_STARTUP_SOLENOID_FAULT_TEST	0	1	1	0 - disabled, 1 - enabled at startup
Solenoid Test Execution Counter (R)	Number of solenoid fault tests carried out since last boot.	SOLENOID_FAULT_TEST_CNTR	0	255	0	Number of tests
Valve Adaptation Algorithm Maximum Broken Valves Limit Service 1 (R/W)	Maximum number of broken valves assigned to Service 1 to maintain operation with valve adaptation algorithm. If more valves are broken, the "Valve adaptation algorithm failed - too many valves broken" error is triggered.	VALVE_ADPT_ALG_MAX_BRKN_VALVS_LIM_S1	0	11	0	Number of broken valves
Valve Adaptation Algorithm Maximum Broken Valves Limit Service 2 (R/W)	Maximum number of broken valves assigned to Service 2 to maintain operation with valve adaptation algorithm. If more valves are broken, the "Valve adaptation algorithm failed - too many valves broken" error is triggered.	VALVE_ADPT_ALG_MAX_BRKN_VALVS_LIM_S2	0	11	0	Number of broken valves
Valve Adaptation Algorithm Maximum Broken Valves Limit Service 3 (R/W)	Maximum number of broken valves assigned to Service 1 to maintain operation with valve adaptation algorithm. If more valves are broken, the "Valve adaptation algorithm failed - too many valves broken" error is triggered.	VALVE_ADPT_ALG_MAX_BRKN_VALVS_LIM_S3	0	11	0	Number of broken valves
Limp Mode Number of Required Valves Service 1 (R/W)	The number of pumping units which should be enabled for the service when Limp Home Mode is active.	LIMP_MODE_NUM_REQ_VALVES_S1	1	3	1	Limp Home Mode is not included in this release
Limp Mode Number of Required Valves Service 2 (R/W)	The number of pumping units which should be enabled for the service when Limp Home Mode is active.	LIMP_MODE_NUM_REQ_VALVES_S2	1	3	1	Limp Home Mode is not included in this release
Limp Mode Number of Required Valves Service 3 (R/W)	The number of pumping units which should be enabled for the service when Limp Home Mode is active.	LIMP_MODE_NUM_REQ_VALVES_S3	1	3	1	Limp Home Mode is not included in this release

8.8 Commissioning mode parameters

The parameters are used during Commissioning mode.

Name (read, write)	Description	Service Tool Parameter Name	Limit Min	Limit Max	Default Value	Notes
Enable Commissioning (R/W)	To enter Commissioning Mode, set to "enabled", then power cycle the controller. To exit, set to "disabled", then power cycle the controller.	EN_COMMISS	0	1	0	0 - disabled, 1 - enabled
Commissioning Action Type 1 (R/W)	Chooses between different Commissioning Mode actions. Fire: actuates the specified coil as soon as possible. Pump: actuates the specified coil at the correct shaft position to enable the pumping unit to pump a full stroke. Service configuration change: updates the service configuration to the desired pre-defined configuration. Raw Displacement: actuates coils as necessary to achieve the desired percentage of displacement.	COMMISS_ACT_TYPE_1	0	6	0	0- off, 1- fire, 2- pump, 3- service configuration change, 4- raw displacement service 1, 5- raw displacement service 2, 6- raw displacement service 3
Commissioning Action Type 2 (R/W)	Coils that correspond to set bits are enabled for Fire or Pump actions. See Coil enabling section for more details.	COMMISS_ACT_TYPE_2	0	4095	0	0- all disabled, 1- enable A1, ... , 4095- all enabled
Commissioning Value (R/W)	Specifies the number of pumping strokes or raw displacement for the corresponding Commissioning Action Type.	COMMISS_VALUE_1	0	10000	0	number of strokes OR raw displacement value
Commissioning Command (R/W)	For Fire and Pump actions, transition from 0 to 1 starts the action. Must be reset to 0 before starting action again. For Raw Displacement action, pump will produce desired displacement while set to 1 and stop pumping when set to 0.	COMMISS_CMD	0	1	0	0- off, 1- start
Commissioning Level (R)	Indicates what level of commissioning operation can be done on the pump due to severity of active errors.	COMMISS_LEVEL	0	2	0	0 - disabled, 1 - firing, 2 - pumping
Commissioning Status (R)	Indicates if an action is off, running, or denied.	COMMISS_STATUS	0	2	0	0- off, 1- running, 2- denied

9 Errors

The DDP096 software contains an error-handling system which is designed to protect the pump and system from undesirable behavior when there is an error detected with the software, communications, DPC12 hardware, sensors or DDP096 pump.

The error handling system consists of a number of errors (see Error list section) each of which has a severity which governs the error handler's response when the error is detected. The effect of each severity is:

- Info: no effect on operation.
- Warning: normal operation stopped. Error ignored in disabled state (when SUPPORT_DM13_PGN parameter is enabled).
- Critical: normal operation stopped.
- Severe: normal operation stopped. Fault state cannot be reset by DM11 message.

Two mechanisms exist to return the controller to an active state following a fault - the J1939 DM11 message (see DM11 PGN - diagnostics data clear of active DTCs section) or power-cycling the DPC12 controller.

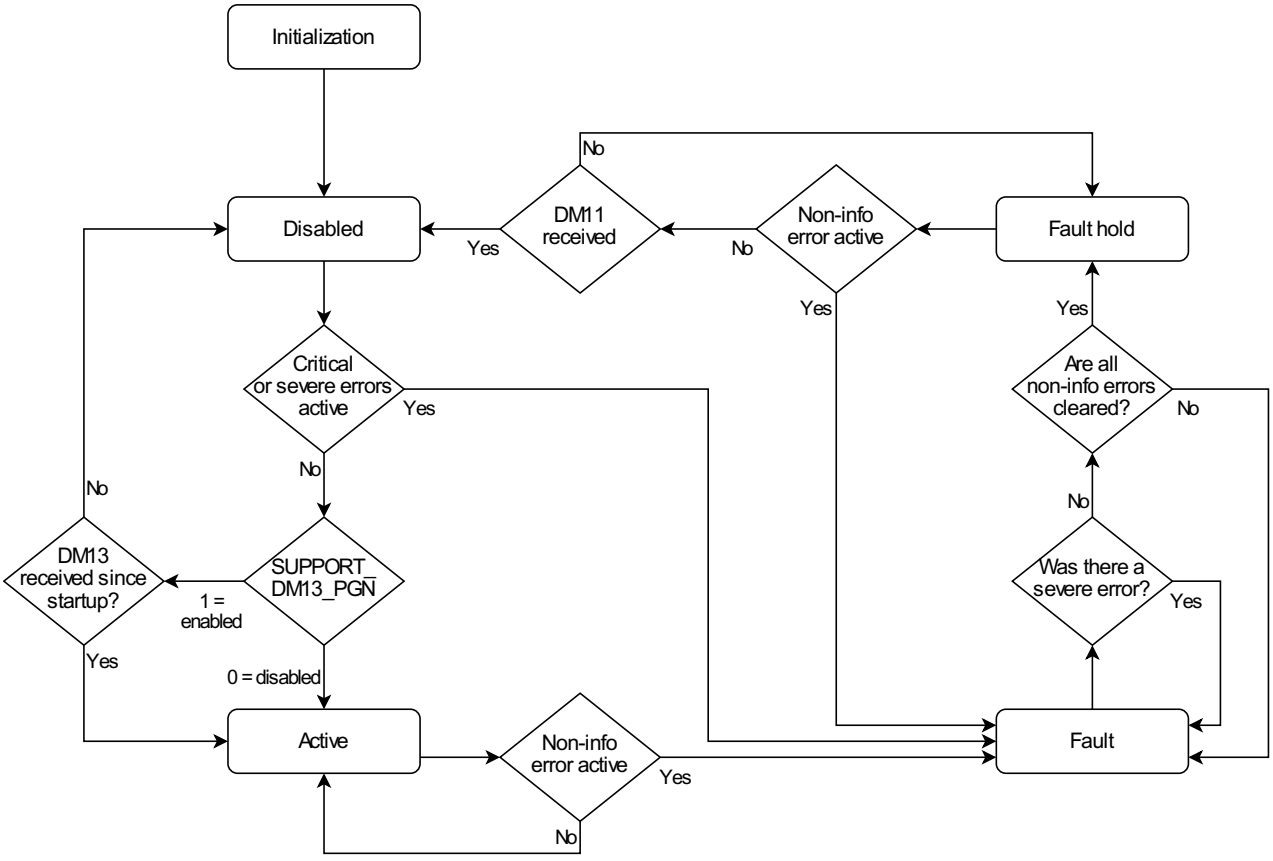
Active and previously active errors can be read over CAN bus using standard J1939 mechanisms (see DM1 PGN - active diagnostic trouble codes and DM2 PGN - previously active diagnostics trouble codes sections) or by using the PLUS+1® Service Tool to read the associated parameters. The PLUS+1® Service Tool can also display counters for the number of times each error has occurred since the last error counter reset (via the DM3 message, see DM3 PGN - diagnostics data clear of previously active DTCs section, or RESET_ERR_CNTR_CMD parameter).

9.1 Error handler states

The error handler component operates as a state machine for the whole DDP096 software. The states are explained in the table below.

State	DEVICE_STATE code	Description
Initialization	0	Start-up state
Disabled	1	Software is held in this state until reception of DM13 message if SUPPORT_DM13_PGN parameter is enabled.
Active	2	Normal operation
Fault	3	There is an active fault of severity warning, critical or severe, or there was previously a severe fault. Pump does not operate.
Fault hold	4	All previous faults non-severe faults have been cleared, but software remains inactive until reception of DM11 message.

The transitions between states are shown in the flowchart below.



9.1.1 Using the disabled state with DM13

The disabled state is provided to allow some errors to be ignored during system start-up. This is intended for use in systems where some errors may be present briefly during the system start-up such as

- vehicles, where the power supply voltage may be lower than the error threshold for a time (such as during engine cranking).
- J1939 controlled systems, where CAN bus messages may not be sent by the system controller for some time after power on, causing PGN timeout errors.

In the disabled state warning and info level errors are ignored and will not be reported or cause a fault state to be triggered until the software moves to the active state. Any critical or severe errors occurring in the disabled state will cause the error handler to move to the fault state as normal. See the Error list for the severities of each error.

The error handler will enter the disabled state after initialization when the SUPPORT_DM13_PGN parameter is enabled. When a DM13 J1939 message is received (see DM13 PGN - ignore all info and warning errors until DM13 is received section) the software will transition to the active state (or the fault state if any errors are present). The DDP096 software will not enter the disabled state again until the controller is restarted.

The disabled state is automatically skipped at start-up unless the SUPPORT_DM13_PGN parameter is enabled.

The DDP096 software implementation of the DM13 message is different to that described in the J1939 specification.

9.2 Error list

SPN	FMI	Name	Description	Severity	Service Tool name for active error	Service Tool name for error counter
168	3	Power supply above limit	Power supply voltage greater than 36V.	WARNING	ERR_AE_168_03_LM_SPLYVIN	ERR_OC_168_03_LM_SPLYVIN
168	4	Power supply below limit	Power supply voltage less than 9V.	WARNING	ERR_AE_168_04_LM_SPLYVIN	ERR_OC_168_04_LM_SPLYVIN

SPN	FMI	Name	Description	Severity	Service Tool name for active error	Service Tool name for error counter
441	16	Controller temperature above limit	Internal controller temperature above limit.	CRITICAL	ERR_AE_441_16_LM_CTEMP	ERR_OC_441_16_LM_CTEMP
441	17	Controller temperature below limit	Controller temperature below -40°C. Pumping will not be affected.	INFO	ERR_AE_441_17_LM_CTEMP	ERR_OC_441_17_LM_CTEMP
442	16	Pump temperature above limit	Pump temperature above 90°C.	CRITICAL	ERR_AE_442_16_LM_PTEMP	ERR_OC_442_16_LM_PTEMP
442	17	Pump temperature below limit	Pump temperature below -20°C. Pumping will not be affected. Error will clear once temperature rises above limit.	INFO	ERR_AE_442_17_LM_PTEMP	ERR_OC_442_17_LM_PTEMP
2848	31	J1939 Name conflict	The configured J1939 Name of the DPC12 controller conflicted with another device on the CAN bus during the address claim procedure. The controller will not communicate over J1939. Ensure all DPC12 controllers on the bus have their FUN_ECU_INSTANCE parameters set to a unique value.	SEVERE	ERR_AE_2848_31_CA_NAME_CLM	ERR_OC_2848_31_CA_NAME_CLM
3599	2	Internal 24V out of range	Internal 24V power supply is out of range. Check that coil power supply pins are powered with the correct voltage. If error persists, contact Danfoss for help.	SEVERE	ERR_AE_3599_02_LM_OUT24V	ERR_OC_3599_02_LM_OUT24V
8621	2	EEPROM CRC fault	Parameter data in non-volatile memory is corrupted and pump cannot operate. Connect with PLUS+1® Service Tool and reset values in controller.	SEVERE	ERR_AE_8621_02_COM_ROMCRC	ERR_OC_8621_02_COM_ROMCRC
8621	11	EEPROM SPI fault	A communication error has occurred when accessing non-volatile memory. No action is required.	INFO	ERR_AE_8621_11_COM_ROMSPI	ERR_OC_8621_11_COM_ROMSPI
8621	31	EEPROM occurrence counter CRC fault	Error occurrence counter data in non-volatile memory is corrupted. Counters will be reset to zero.	WARNING	ERR_AE_8621_31_COM_ROMCRC_OC	ERR_OC_8621_31_COM_ROMCRC_OC
520960	0	Service 1 outlet pressure too high	Outlet pump pressure above pressure limit, as set by PRESS_ERROR_LIM parameter.	SEVERE	ERR_AE_520960_00_SENSOR_OUTPRESS_S1	ERR_OC_520960_00_SENSOR_OUTPRESS_S1
520960	2	Service 1 outlet pressure sensor incorrect	Analog outlet pressure sensor signal is erratic or unstable. Check that sensor and connectors are properly secured and for damage to sensor wires or sensor. Repair as necessary. If no damage exists and error persists, or to obtain replacement parts, contact Danfoss for help.	SEVERE	ERR_AE_520960_02_SENSOR_OUTPRESS_S1	ERR_OC_520960_02_SENSOR_OUTPRESS_S1
520960	16	Service 1 outlet pressure reading above maximum	Analog outlet pressure sensor signal is above the valid 4-20 mA range. Check that sensor and connectors are properly secured and for damage to sensor wires or sensor. Repair as necessary. If no damage exists and error persists, or to obtain replacement parts, contact Danfoss for help.	SEVERE	ERR_AE_520960_16_SENSOR_OUTPRESS_S1	ERR_OC_520960_16_SENSOR_OUTPRESS_S1
520960	18	Service 1 outlet pressure reading below minimum	Analog outlet pressure sensor signal is below the valid 4-20 mA range. Check that sensor and connectors are properly secured and for damage to sensor wires or sensor. Repair as necessary. If no damage exists and error persists, or to obtain replacement parts, contact Danfoss for help.	SEVERE	ERR_AE_520960_18_SENSOR_OUTPRESS_S1	ERR_OC_520960_18_SENSOR_OUTPRESS_S1
520961	0	Service 2 outlet pressure too high	Outlet pump pressure above pressure limit, as set by PRESS_ERROR_LIM parameter.	SEVERE	ERR_AE_520961_00_SENSOR_OUTPRESS_S2	ERR_OC_520961_00_SENSOR_OUTPRESS_S2
520961	2	Service 2 outlet pressure sensor incorrect	Analog outlet pressure sensor signal is erratic or unstable. Check that sensor and connectors are properly secured and for damage to sensor wires or sensor. Repair as necessary. If no damage exists and error persists, or to obtain replacement parts, contact Danfoss for help.	SEVERE	ERR_AE_520961_02_SENSOR_OUTPRESS_S2	ERR_OC_520961_02_SENSOR_OUTPRESS_S2
520961	16	Service 2 outlet pressure reading above maximum	Analog outlet pressure sensor signal is above the valid 4-20 mA range. Check that sensor and connectors are properly secured and for damage to sensor wires or sensor. Repair as necessary. If no damage exists and error persists, or to obtain replacement parts, contact Danfoss for help.	SEVERE	ERR_AE_520961_16_SENSOR_OUTPRESS_S2	ERR_OC_520961_16_SENSOR_OUTPRESS_S2
520961	18	Service 2 outlet pressure reading below minimum	Analog outlet pressure sensor signal is below the valid 4-20 mA range. Check that sensor and connectors are properly secured and for damage to sensor wires or sensor. Repair as necessary. If no damage exists and error persists, or to obtain replacement parts, contact Danfoss for help.	SEVERE	ERR_AE_520961_18_SENSOR_OUTPRESS_S2	ERR_OC_520961_18_SENSOR_OUTPRESS_S2
520962	0	Service 3 outlet pressure too high	Outlet pump pressure above pressure limit, as set by PRESS_ERROR_LIM parameter.	SEVERE	ERR_AE_520962_00_SENSOR_OUTPRESS_S3	ERR_OC_520962_00_SENSOR_OUTPRESS_S3

SPN	FMI	Name	Description	Severity	Service Tool name for active error	Service Tool name for error counter
520962	2	Service 3 outlet pressure sensor incorrect	Analog outlet pressure sensor signal is erratic or unstable. Check that sensor and connectors are properly secured and for damage to sensor wires or sensor. Repair as necessary. If no damage exists and error persists, or to obtain replacement parts, contact Danfoss for help.	SEVERE	ERR_AE_520962_02_SENSOR_OUTPRESS_S3	ERR_OC_520962_02_SENSOR_OUTPRESS_S3
520962	16	Service 3 outlet pressure reading above maximum	Analog outlet pressure sensor signal is above the valid 4-20 mA range. Check that sensor and connectors are properly secured and for damage to sensor wires or sensor. Repair as necessary. If no damage exists and error persists, or to obtain replacement parts, contact Danfoss for help.	SEVERE	ERR_AE_520962_16_SENSOR_OUTPRESS_S3	ERR_OC_520962_16_SENSOR_OUTPRESS_S3
520962	18	Service 3 outlet pressure reading below minimum	Analog outlet pressure sensor signal is below the valid 4-20 mA range. Check that sensor and connectors are properly secured and for damage to sensor wires or sensor. Repair as necessary. If no damage exists and error persists, or to obtain replacement parts, contact Danfoss for help.	SEVERE	ERR_AE_520962_18_SENSOR_OUTPRESS_S3	ERR_OC_520962_18_SENSOR_OUTPRESS_S3
520972	2	J1939 address invalid	The stored configuration for J1939 Name (FUN_ECU_INSTANCE and NODE_ID are invalid. Check the parameters are in the valid range.	SEVERE	ERR_AE_520972_02_CA_ADDRS_CFG	ERR_OC_520972_02_CA_ADDRS_CFG
520972	31	J1939 address claim failure	The DPC12 controller has lost arbitration for the configured J1939 address. The controller will not communicate over J1939. Review device address configuration in the CAN bus system.	SEVERE	ERR_AE_520972_31_CA_ADDRS_CLM	ERR_OC_520972_31_CA_ADDRS_CLM
520975	0	Shaft speed above limit	Shaft speed is too high to pump.	CRITICAL	ERR_AE_520975_00_LM_SHSPD	ERR_OC_520975_00_LM_SHSPD
520975	2	Shaft sensor detection fault	Shaft speed sensor not working properly. Power cycle controller to enable pumping. If error persists, check that connectors are properly secured and for damage to sensor wires or sensor. Repair as necessary. If no damage exists and error persists, or to obtain replacement parts, contact Danfoss for help.	SEVERE	ERR_AE_520975_02_LM_SHSPD	ERR_OC_520975_02_LM_SHSPD
520975	8	Reverse shaft direction	Shaft is rotating in reverse direction (counter-clockwise when looking at input shaft) which is not supported. Correct the direction of rotation.	WARNING	ERR_AE_520975_08_LM_SHSPD	ERR_OC_520975_08_LM_SHSPD
520975	17	Shaft speed below limit	Shaft speed is too low to pump. Pumping disabled. Increase shaft speed to enable pumping.	INFO	ERR_AE_520975_17_LM_SHSPD	ERR_OC_520975_17_LM_SHSPD
520976	2	EEPROM value out of range	A parameter value stored in non-volatile memory is outside its allowed range. Connect with PLUS+1® Service Tool and check values.	CRITICAL	ERR_AE_520976_02_LM_NVDATA	ERR_OC_520976_02_LM_NVDATA
520977	16	Too many errors to handle by J1939 DM1	More than 29 errors active (or previously active) at the same time. J1939 Diagnostic messages DM1 and DM2 are not able to show them all.	CRITICAL	ERR_AE_520977_16_LM_FAULTMAX	ERR_OC_520977_16_LM_FAULTMAX
520978	9	CAN bus displacement reference timeout	J1939 displacement reference message is required by current control mode configuration and was not received within the timeout window. Check configuration, message content and sending frequency.	WARNING	ERR_AE_520978_09_TL_DSREF	ERR_OC_520978_09_TL_DSREF
520979	9	CAN bus torque limit timeout	J1939 torque limit message is required by current limit configuration and was not received within the timeout window. Check configuration, message content and sending frequency.	WARNING	ERR_AE_520979_09_TL_TQLIM	ERR_OC_520979_09_TL_TQLIM
520980	9	CAN bus pressure reference timeout	J1939 pressure reference message is required by current control mode configuration and was not received within the timeout window. Check configuration, message content and sending frequency.	WARNING	ERR_AE_520980_09_TL_PRREF	ERR_OC_520980_09_TL_PRREF
520981	9	CAN bus pressure margin timeout	J1939 pressure margin reference message is required by current control mode configuration and was not received within the timeout window. Check configuration, message content and sending frequency.	WARNING	ERR_AE_520981_09_TL_PMREF	ERR_OC_520981_09_TL_PMREF
520982	9	CAN bus power limit timeout	J1939 power limit message is required by current limit configuration and was not received within the timeout window. Check configuration, message content and sending frequency.	WARNING	ERR_AE_520982_09_TL_PWRLIM	ERR_OC_520982_09_TL_PWRLIM
520983	9	CAN bus pump enable/service index timeout	J1939 pump setup message is required by current configuration and was not received within the timeout window. Check configuration, message content and sending frequency.	WARNING	ERR_AE_520983_09_TL_PMPEN	ERR_OC_520983_09_TL_PMPEN

SPN	FMI	Name	Description	Severity	Service Tool name for active error	Service Tool name for error counter
520984	9	CAN bus flow limit timeout	J1939 flow limit message is required by current limit configuration and was not received within the timeout window. Check configuration, message content and sending frequency.	WARNING	ERR_AE_520984_09_TL_FLLIM	ERR_OC_520984_09_TL_FLLIM
520987	16	Service 1 broken valves above maximum	Too many valves are not functioning properly. Check other error codes to see which valves are not functioning. For further help, contact Danfoss.	CRITICAL	ERR_AE_520987_16_LM_BROKENVLVMAX_S1	ERR_OC_520987_16_LM_BROKENVLVMAX_S1
520988	16	Service 2 broken valves above maximum	Too many valves are not functioning properly. Check other error codes to see which valves are not functioning. For further help, contact Danfoss.	CRITICAL	ERR_AE_520988_16_LM_BROKENVLVMAX_S2	ERR_OC_520988_16_LM_BROKENVLVMAX_S2
520989	16	Service 3 broken valves above maximum	Too many valves are not functioning properly. Check other error codes to see which valves are not functioning. For further help, contact Danfoss.	CRITICAL	ERR_AE_520989_16_LM_BROKENVLVMAX_S3	ERR_OC_520989_16_LM_BROKENVLVMAX_S3
520995	1	Service 1 unbroken valves below limping minimum	Not implemented in this version	SEVERE	ERR_AE_520995_01_LM_LIMPVLVMIN_S1	ERR_OC_520995_01_LM_LIMPVLVMIN_S1
520996	1	Service 2 unbroken valves below limping minimum	Not implemented in this version	SEVERE	ERR_AE_520996_01_LM_LIMPVLVMIN_S2	ERR_OC_520996_01_LM_LIMPVLVMIN_S2
520997	1	Service 3 unbroken valves below limping minimum	Not implemented in this version	SEVERE	ERR_AE_520997_01_LM_LIMPVLVMIN_S3	ERR_OC_520997_01_LM_LIMPVLVMIN_S3
521003	2	Internal 3.3V out of range	Internal 3.3V power supply is out of range. If error persists, contact Danfoss for help.	SEVERE	ERR_AE_521003_02_LM_OUT3V3	ERR_OC_521003_02_LM_OUT3V3
521005	2	Invalid data in J1939 message	Data in at least one J1939 CAN message is outside range limits. CAN message is ignored. Ensure that J1939 CAN messages are implemented correctly for all required CAN messages. For CAN message definitions, refer J1939 CAN protocol section.	WARNING	ERR_AE_521005_02_INVALID_DATA	ERR_OC_521005_02_INVALID_DATA
521007	11	Control core internal error	Runtime error occurred in the control core. If error persists, contact Danfoss for help.	SEVERE	ERR_AE_521007_11_CTRL_ABORT	ERR_OC_521007_11_CTRL_ABORT
521008	2	FPGA communication error	No or incorrect response received from FPGA. If error persists, contact Danfoss for help.	SEVERE	ERR_AE_521008_02_COM_SPIFPGA	ERR_OC_521008_02_COM_SPIFPGA
521009	2	CAN bus error passive	Too many CAN bus communication errors detected. Check CAN bus wiring, baud rate settings and other devices on the bus are operating correctly. If error persists, contact Danfoss for help.	WARNING	ERR_AE_521009_02_COM_CANEPV	ERR_OC_521009_02_COM_CANEPV
521010	12	RAM test failure	RAM test failed. If error persists, contact Danfoss for help.	SEVERE	ERR_AE_521010_12_COM_RAMTEST	ERR_OC_521010_12_COM_RAMTEST
521020	2	Service 1 external load-sense pressure sensor incorrect	Analog load-sense pressure sensor signal is erratic or unstable. Additional sensor is required when CONTROL_MODE_S1 parameter is set to load-sense mode. Check that sensor and connectors are properly secured and for damage to sensor wires or sensor. Repair as necessary. If no damage exists and error persists, or to obtain replacement parts, contact Danfoss for help.	CRITICAL	ERR_AE_521020_02_SENSOR_LSPRESS_S1	ERR_OC_521020_02_SENSOR_LSPRESS_S1
521020	16	Service 1 external load-sense pressure reading above maximum	Analog load-sense pressure sensor signal is above the valid 4-20 mA range. Additional sensor is required when CONTROL_MODE_S1 parameter is set to load-sense mode. Check that sensor and connectors are properly secured and for damage to sensor wires or sensor. Repair as necessary. If no damage exists and error persists, or to obtain replacement parts, contact Danfoss for help.	CRITICAL	ERR_AE_521020_16_SENSOR_LSPRESS_S1	ERR_OC_521020_16_SENSOR_LSPRESS_S1
521020	18	Service 1 external load-sense pressure reading below minimum	Analog load-sense pressure sensor signal is below the valid 4-20 mA range. Additional sensor is required when CONTROL_MODE_S1 parameter is set to load-sense mode. Check that sensor and connectors are properly secured and for damage to sensor wires or sensor. Repair as necessary. If no damage exists and error persists, or to obtain replacement parts, contact Danfoss for help.	CRITICAL	ERR_AE_521020_18_SENSOR_LSPRESS_S1	ERR_OC_521020_18_SENSOR_LSPRESS_S1
521021	2	Service 2 external load-sense pressure sensor incorrect	Analog load-sense pressure sensor signal is erratic or unstable. Additional sensor is required when CONTROL_MODE_S2 parameter is set to load-sense mode. Check that sensor and connectors are properly secured and for damage to sensor wires or sensor. Repair as necessary. If no damage exists and error persists, or to obtain replacement parts, contact Danfoss for help.	CRITICAL	ERR_AE_521021_02_SENSOR_LSPRESS_S2	ERR_OC_521021_02_SENSOR_LSPRESS_S2

SPN	FMI	Name	Description	Severity	Service Tool name for active error	Service Tool name for error counter
521021	16	Service 2 external load-sense pressure reading above maximum	Analog load-sense pressure sensor signal is above the valid 4-20 mA range. Additional sensor is required when CONTROL_MODE_S2 parameter is set to load-sense mode. Check that sensor and connectors are properly secured and for damage to sensor wires or sensor. Repair as necessary. If no damage exists and error persists, or to obtain replacement parts, contact Danfoss for help.	CRITICAL	ERR_AE_521021_16_SENSOR_LSPRESS_S2	ERR_OC_521021_16_SENSOR_LSPRESS_S2
521021	18	Service 2 external load-sense pressure reading below minimum	Analog load-sense pressure sensor signal is below the valid 4-20 mA range. Additional sensor is required when CONTROL_MODE_S2 parameter is set to load-sense mode. Check that sensor and connectors are properly secured and for damage to sensor wires or sensor. Repair as necessary. If no damage exists and error persists, or to obtain replacement parts, contact Danfoss for help.	CRITICAL	ERR_AE_521021_18_SENSOR_LSPRESS_S2	ERR_OC_521021_18_SENSOR_LSPRESS_S2
521022	2	Service 3 external load-sense pressure sensor incorrect	Analog load-sense pressure sensor signal is erratic or unstable. Additional sensor is required when CONTROL_MODE_S1 parameter is set to load-sense mode. Check that sensor and connectors are properly secured and for damage to sensor wires or sensor. Repair as necessary. If no damage exists and error persists, or to obtain replacement parts, contact Danfoss for help.	CRITICAL	ERR_AE_521022_02_SENSOR_LSPRESS_S3	ERR_OC_521022_02_SENSOR_LSPRESS_S3
521022	16	Service 3 external load-sense pressure reading above maximum	Analog load-sense pressure sensor signal is above the valid 4-20 mA range. Additional sensor is required when CONTROL_MODE_S1 parameter is set to load-sense mode. Check that sensor and connectors are properly secured and for damage to sensor wires or sensor. Repair as necessary. If no damage exists and error persists, or to obtain replacement parts, contact Danfoss for help.	CRITICAL	ERR_AE_521022_16_SENSOR_LSPRESS_S3	ERR_OC_521022_16_SENSOR_LSPRESS_S3
521022	18	Service 3 external load-sense pressure reading below minimum	Analog load-sense pressure sensor signal is below the valid 4-20 mA range. Additional sensor is required when CONTROL_MODE_S1 parameter is set to load-sense mode. Check that sensor and connectors are properly secured and for damage to sensor wires or sensor. Repair as necessary. If no damage exists and error persists, or to obtain replacement parts, contact Danfoss for help.	CRITICAL	ERR_AE_521022_18_SENSOR_LSPRESS_S3	ERR_OC_521022_18_SENSOR_LSPRESS_S3
521040	6	Valve #1 solenoid current failed	Valve number 1 (A1) solenoid failed to build current as expected during solenoid current test. Valve is disabled and adaptation algorithm is used to allow pumping using the rest of the working valves. Check for a disconnected harness to the solenoid or another wiring issue. For replacement parts or further help, contact Danfoss.	INFO	ERR_AE_521040_06_VC_1A1	ERR_OC_521040_06_VC_1A1
521040	7	Valve #1 pumping failed	Not implemented in this version	INFO	ERR_AE_521040_07_VM_1A1	ERR_OC_521040_07_VM_1A1
521041	6	Valve #2 solenoid current failed	Valve number 2 (B1) solenoid failed to build current as expected during solenoid current test. Valve is disabled and adaptation algorithm is used to allow pumping using the rest of the working valves. Check for a disconnected harness to the solenoid or another wiring issue. For replacement parts or further help, contact Danfoss.	INFO	ERR_AE_521041_06_VC_1B1	ERR_OC_521041_06_VC_1B1
521041	7	Valve #2 pumping failed	Not implemented in this version	INFO	ERR_AE_521041_07_VM_1B1	ERR_OC_521041_07_VM_1B1
521042	6	Valve #3 solenoid current failed	Valve number 3 (C1) solenoid failed to build current as expected during solenoid current test. Valve is disabled and adaptation algorithm is used to allow pumping using the rest of the working valves. Check for a disconnected harness to the solenoid or another wiring issue. For replacement parts or further help, contact Danfoss.	INFO	ERR_AE_521042_06_VC_1C1	ERR_OC_521042_06_VC_1C1
521042	7	Valve #3 pumping failed	Not implemented in this version	INFO	ERR_AE_521042_07_VM_1C1	ERR_OC_521042_07_VM_1C1
521043	6	Valve #4 solenoid current failed	Valve number 4 (A2) solenoid failed to build current as expected during solenoid current test. Valve is disabled and adaptation algorithm is used to allow pumping using the rest of the working valves. Check for a disconnected harness to the solenoid or another wiring issue. For replacement parts or further help, contact Danfoss.	INFO	ERR_AE_521043_06_VC_1A2	ERR_OC_521043_06_VC_1A2

SPN	FMI	Name	Description	Severity	Service Tool name for active error	Service Tool name for error counter
521043	7	Valve #4 pumping failed	Not implemented in this version	INFO	ERR_AE_521043_07_VM_1A2	ERR_OC_521043_07_VM_1A2
521044	6	Valve #5 solenoid current failed	Valve number 5 (B2) solenoid failed to build current as expected during solenoid current test. Valve is disabled and adaptation algorithm is used to allow pumping using the rest of the working valves. Check for a disconnected harness to the solenoid or another wiring issue. For replacement parts or further help, contact Danfoss.	INFO	ERR_AE_521044_06_VC_1B2	ERR_OC_521044_06_VC_1B2
521044	7	Valve #5 pumping failed	Not implemented in this version	INFO	ERR_AE_521044_07_VM_1B2	ERR_OC_521044_07_VM_1B2
521045	6	Valve #6 solenoid current failed	Valve number 6 (C2) solenoid failed to build current as expected during solenoid current test. Valve is disabled and adaptation algorithm is used to allow pumping using the rest of the working valves. Check for a disconnected harness to the solenoid or another wiring issue. For replacement parts or further help, contact Danfoss.	INFO	ERR_AE_521045_06_VC_1C2	ERR_OC_521045_06_VC_1C2
521045	7	Valve #6 pumping failed	Not implemented in this version	INFO	ERR_AE_521045_07_VM_1C2	ERR_OC_521045_07_VM_1C2
521046	6	Valve #7 solenoid current failed	Valve number 7 (A3) solenoid failed to build current as expected during solenoid current test. Valve is disabled and adaptation algorithm is used to allow pumping using the rest of the working valves. Check for a disconnected harness to the solenoid or another wiring issue. For replacement parts or further help, contact Danfoss.	INFO	ERR_AE_521046_06_VC_1A3	ERR_OC_521046_06_VC_1A3
521046	7	Valve #7 pumping failed	Not implemented in this version	INFO	ERR_AE_521046_07_VM_1A3	ERR_OC_521046_07_VM_1A3
521047	6	Valve #8 solenoid current failed	Valve number 8 (B3) solenoid failed to build current as expected during solenoid current test. Valve is disabled and adaptation algorithm is used to allow pumping using the rest of the working valves. Check for a disconnected harness to the solenoid or another wiring issue. For replacement parts or further help, contact Danfoss.	INFO	ERR_AE_521047_06_VC_1B3	ERR_OC_521047_06_VC_1B3
521047	7	Valve #8 pumping failed	Not implemented in this version	INFO	ERR_AE_521047_07_VM_1B3	ERR_OC_521047_07_VM_1B3
521048	6	Valve #9 solenoid current failed	Valve number 9 (C3) solenoid failed to build current as expected during solenoid current test. Valve is disabled and adaptation algorithm is used to allow pumping using the rest of the working valves. Check for a disconnected harness to the solenoid or another wiring issue. For replacement parts or further help, contact Danfoss.	INFO	ERR_AE_521048_06_VC_1C3	ERR_OC_521048_06_VC_1C3
521048	7	Valve #9 pumping failed	Not implemented in this version	INFO	ERR_AE_521048_07_VM_1C3	ERR_OC_521048_07_VM_1C3
521049	6	Valve #10 solenoid current failed	Valve number 10 (A4) solenoid failed to build current as expected during solenoid current test. Valve is disabled and adaptation algorithm is used to allow pumping using the rest of the working valves. Check for a disconnected harness to the solenoid or another wiring issue. For replacement parts or further help, contact Danfoss.	INFO	ERR_AE_521049_06_VC_1A4	ERR_OC_521049_06_VC_1A4
521049	7	Valve #10 pumping failed	Not implemented in this version	INFO	ERR_AE_521049_07_VM_1A4	ERR_OC_521049_07_VM_1A4
521050	6	Valve #11 solenoid current failed	Valve number 11 (B4) solenoid failed to build current as expected during solenoid current test. Valve is disabled and adaptation algorithm is used to allow pumping using the rest of the working valves. Check for a disconnected harness to the solenoid or another wiring issue. For replacement parts or further help, contact Danfoss.	INFO	ERR_AE_521050_06_VC_1B4	ERR_OC_521050_06_VC_1B4
521050	7	Valve #11 pumping failed	Not implemented in this version	INFO	ERR_AE_521050_07_VM_1B4	ERR_OC_521050_07_VM_1B4
521051	6	Valve #12 solenoid current failed	Valve number 12 (C4) solenoid failed to build current as expected during solenoid current test. Valve is disabled and adaptation algorithm is used to allow pumping using the rest of the working valves. Check for a disconnected harness to the solenoid or another wiring issue. For replacement parts or further help, contact Danfoss.	INFO	ERR_AE_521051_06_VC_1C4	ERR_OC_521051_06_VC_1C4
521051	7	Valve #12 pumping failed	Not implemented in this version	INFO	ERR_AE_521051_07_VM_1C4	ERR_OC_521051_07_VM_1C4

9.3 Diagnosing faults

The following methods can be used to diagnose a fault in the DDP096 pump and software:

- View the Diagnostic LED color to establish the current status of the software.
- Use the J1939 DM1 and DM2 messages to identify the active and previously active errors (see DM1 PGN - active diagnostic trouble codes and DM2 PGN - previously active diagnostics trouble codes sections).
- In the PLUS+1® Service Tool:
  - check the DEVICE_MODE and DEVICE_STATE parameters to establish the current status of the software.
  - check the currently active errors using the errors status page (or the active error parameters directly).
  - check the previously active errors using the counters on the error status page (or the error counter parameters directly).
  - use Commissioning mode to allow limited operation with some errors active to diagnose system issues.
- Follow the steps in the Commissioning and troubleshooting section of the Digital Displacement® Pump Gen 1 DDP096 and DPC12 Technical Information.

9.3.1 Diagnostic LED

Color	Blink rate	Meaning
Magenta	Continuous	Device is in boot-loader mode after "Recover ECU" function used in PLUS+1 Service Tool
Magenta blinking	1.5 Hz	Device is in boot-loader mode because no valid application software was found
Blue blinking	Fast irregular	Device is downloading application software
Yellow blinking	1.5 Hz	Device is in commissioning mode
Yellow	Continuous	Device is either waiting for DM13 message to enable the pump, in initialization state directly after power up, or in disabled state
Green	Continuous	Device is in active state
Red	Continuous	Device is in fault or fault hold state
Red blinking	1.5 Hz	J1939 address claim error, CAN bus will not operate
Alternating red/green	1.5 Hz	Device is in limp home mode and there is no severe error

10 J1939 CAN protocol

The DDP096 software on the DPC12 can be commanded dynamically during use with a system controller, testing application or other CAN bus-capable device. The software also reports the current operating status and its error signals over the bus.

The protocol used is based on the automotive SAE J1939 protocol which is transmitted over a standard CAN bus connection. This manual does not aim to describe all of the features of J1939. However, it is possible to control the pump by sending standard CAN frames (with 29-bit IDs) formatted to match the J1939 protocol implementation. Please refer to SAE publications or contact your Danfoss representative for further advice.

Two important concepts for the transmission and reception of J1939 messaged are Parameter Group Numbers (PGNs), which identify the purpose and format of a particular message containing data, and Suspect Parameter Numbers (SPNs), which identify particular signals or parameters contained within a message. The J1939 standard specifies many PGNs and SPNs and leaves space for manufacturers to specify their own when needed. The standard also uses the term Diagnostic Trouble Code (DTC), each of which represents an error in the system.

CAN messages are limited to eight data bytes. When data longer than this is sent, a multi-packet message is sent using the Broadcast Announce Message (BAM) mechanism. The TP.CM_BAM (BAM) message is used to inform all the nodes of the network that a large message is about to be broadcast. It defines the parameter group and the number of bytes to be sent. After a BAM message is sent, the TP.DT messages are sent and they contain the packetized broadcast data.

10.1 Address scheme

Each device on a J1939 network must be uniquely addressable to be able to send and receive messages. This is achieved through use of a J1939 Name to uniquely identify the function of a device on the network and an address given to each device which is used during the communications.

The fields of the J1939 Name assigned to the controller are shown in the table below.

J1939 Name field	Length (bits)	Value
Arbitrary address bit	1	0
Industry group	3	3
Vehicle system instance	4	0
Vehicle system	7	0
Function	8	255
Function instance	5	Set by FUN_ECU_INSTANCE
ECU instance	3	Set by FUN_ECU_INSTANCE
Manufacturer code	11	57
Identity number	21	200200

When using more than one DPC12 controller on the network, a unique FUN_ECU_INSTANCE value must be assigned to each controller in order to ensure that each device has a unique J1939 Name and can therefore be assigned an address on the J1939 network.

- FUN_ECU_INSTANCE: This parameter sets the ECU Instance and Function Instance values which form part of the J1939 Name of the device, allowing the user to give each device a unique name in the system. Any value which is not shared with another DPC12 controller will allow the system to operate correctly.

Bit no.	Value/range	Description
0...2	0...7	ECU Instance
3...7	0...31	Functional Instance

A group of controllers are often required to perform a specific function in a system. In complex systems, the same function may be implemented more than once. To identify which instance of a function a particular controller belongs to, the Functional Instance is used. The ECU Instance is used to identify a particular controller within an instance of a function. Consider, for example, a braking system which has two controllers -

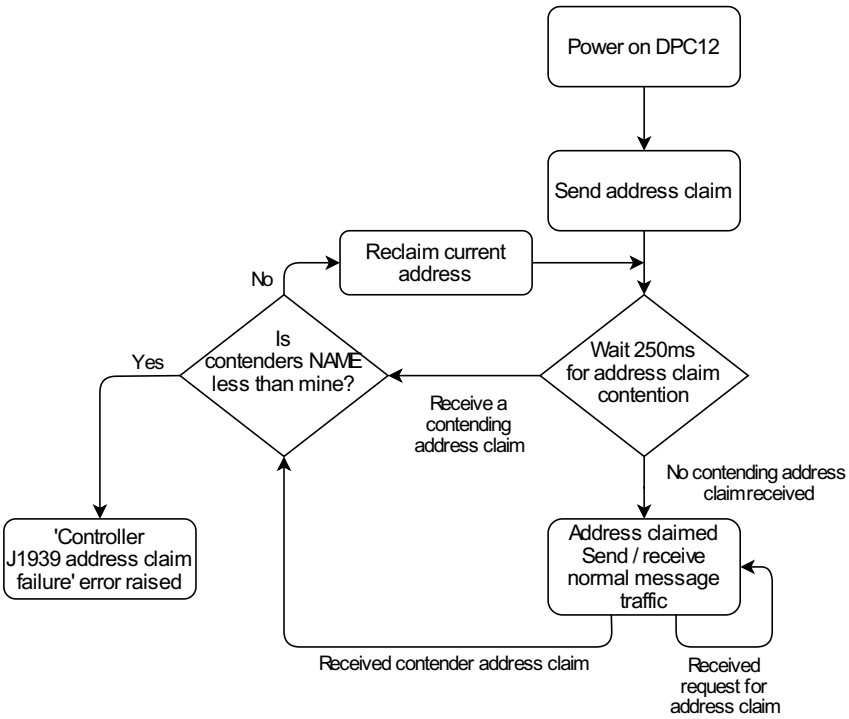
each controller would have a different ECU Instance, but the same Functional Instance as both controllers are required to perform the braking function. Now, consider that this brake system is replicated on each wheel of a vehicle - the controllers on each wheel would be able to keep their existing ECU Instance values, however the Functional Instance values would have to be unique to each wheel.

- NODE_ID: This parameter sets the address which the DPC12 controller will attempt to claim on start-up. This value must not be in use by any other DPC12 controller, and should also not be used by any other device on the bus. Note this parameter is also used by the PLUS+1® Service Tool to identify the DPC12 controller.

On start-up the DPC12 controller will initiate an address claim procedure where it attempts to claim the address configured by the NODE_ID parameter. The result of the claim procedure will be one of the following:

- The address is claimed successfully, and the controller starts communication.
- The address cannot be claimed because a device with a higher-priority J1939 Name has claimed this address. An address claim failure error will be raised.
- Another device on the network with the same J1939 Name is detected, usually another DPC12 with the same value of the FUN_ECU_INSTANCE parameter. A name conflict error will be raised.

An outline of this procedure is shown in this flowchart:



For the full address claim procedure refer to SAE J1939 standard or contact your Danfoss representative.

10.2 PGN priorities

The three-bit priority field in J1939 is intended to give the system designer the ability to prioritize messages on the bus, with a lower number giving the message a higher priority. In the current implementation the messages received by the DPC12 controller will only be read correctly if a specific priority (3) is used. This behavior will be changed in a future software update to give flexibility in the priorities used.

All received J1939 priorities must match the message information table to be received correctly.

10.3 SLOTs

J1939 uses standard SLOTs (scaling, limit, offset and transfer function) to represent physical quantities as data in the J1939 CAN frames. As well as using standard SLOTs, the DDP096 software uses several custom SLOTs where a standard SLOT was not available. These SLOTs are named with a DD prefix. Details of each SLOT used

in the software are given in the table below. Full details can be found in the J1939 Digital Annex, available from the SAE.

SLOT name	SLOT type	Scaling	Range	Offset	Length
SAEbs04	Bit field	16 states/4 bit	0 to 15	0	4 bits
SAEbs08	Bit field	256 states/8 bit	0 to 255	0	8 bits
SAEbm16	Bit mapped	16 bit bit-mapped	bit-mapped	0	16 bits
SAEpc11	Percent, position/level	0.005%/bit	-150 to 171.275%	-150 %	2 bytes
SAEpr08	Pressure	2 kPa/bit	0 to 128,510 kPa	0	2 bytes
SAEpw08	Power, real	0.05 kW/bit	-1600 to 1612.75 kW	-1600 kW	2 bytes
SAEtp01	Temperature	1 °C/bit	-40 to 210 °C	-40 °C	1 byte
SAEvr07	Velocity, rotational	1 rpm per bit	-32127 to 32128 rpm	-32127 rpm	2 bytes
DDtq01	Torque	0.2 Nm/bit	-6400 to 6451 Nm	-6400 Nm	2 bytes
DDfl02	Flow rate	0.05 L/min/bit	-1600 to 1612.75 L/min	-1600 L/min	2 bytes

Where a SLOT used in J1939 communication has higher resolution than the corresponding PLUS+1® Service Tool parameter, the value will be truncated (rounded down) to match the parameter resolution. If a different rounding method is desired the system controller code should include the rounding to the parameter's precision before sending the value over J1939. This behavior will be changed in a future software update to allow the full resolution of the SLOTs to be used for more precise control.

10.4 Diagnostic messages

Several standard J1939 diagnostic messages are implemented in the controller.

Each diagnostic message is detailed in the following sections. Example sequences of J1939 message frames in different circumstances are given for each diagnostic message.

In all example message identifiers ("msg ID"s) the system controller node ID in hexadecimal is indicated by yy and the DPC12 node ID is indicated by zz. Following the J1939 standard, the destination address for any message can be set to 0xFF rather than a specific DPC12 node ID to send a message to all nodes in the system.

10.4.1 DM1 PGN - active diagnostic trouble codes

The DM1 PGN communicates the details of the errors (DTCs) which are currently active in the DDP096 software.

If more than one error is active, a BAM session is used to communicate the active errors. The maximum number of errors that can be sent by BAM session is 30. If there are 29 active errors at the same time, the "Too many errors to handle by J1939" error is automatically raised, which is the 30th error in the BAM session.

10.4.1.1 Message information

When only one error is active a single message is sent with the following information:

Name	DM1
Priority	6
Data page	0
PDU format	0xFE
PDU specific	0xCA
Source address	DPC12 node ID (zz)
Full message ID	0x18FECAzz
DLC (length)	8
Direction	Transmitted by DPC12
Occurrence	Periodic — every 1s or on occurrence or disappearance of error

10.4.1.2 Message data

When only one error is active a single message is sent with the following format:

Byte no.	Bits	Encoding	Value/range	Description
0		U8	0x04: Amber lamp (info or warning error) 0x10: Red lamp (severe or critical error)	Lamp status
1		U8	0xFF	Flash status
2		U8	0x00...0xFF	LSB of SPN (suspect part number)
3		U8	0x00...0xFF	Next LSB of SPN
4	0...4		0x00...0x1F	FMI (failure mode indicator)
4	5...7		0x00...0x07	MSB of SPN
5	0...6		0x00...0x7F	Occurrence count
5	7		0x00	Conversion method
6...7			All bits set to 1	Reserved

10.4.1.3 DM1 example scenarios

The following scenarios describe the DM1 transmissions based on specific situations.

10.4.1.3.1 Scenario 1 - single active error

If there is only one active error in the system, the DDP096 software on the DPC12 will send out the DM1 message as follows. This indicates that an error with an SPN of 0x07F312 (520978) and an FMI of 0x09 (9) with warning severity is active, and has occurred three times.

Type	Msg ID	DLC	Byte0	Byte1	Byte2	Byte3	Byte4	Byte5	Byte6	Byte7
DM1	0x18FECAzz	8	0x04	0xFF	0x12	0xF3	0xE9	0x03	0xFF	0xFF
		8	Lamp status	Flash status	SPN1	SPN2	SPN3/FMI	OC	Reserved	Reserved

10.4.1.3.2 Scenario 2 - no active errors

If there are no active errors in the system, the DDP096 software on the DPC12 will send out the DM1 message as follows:

Type	Msg ID	DLC	Byte0	Byte1	Byte2	Byte3	Byte4	Byte5	Byte6	Byte7
DM1	0x18FECAzz	8	0x00	0xFF	0x00	0x00	0x00	0x00	0xFF	0xFF
		8	Lamp status	Flash status	SPN1	SPN2	SPN3/FMI	OC	Reserved	Reserved

10.4.1.3.3 Scenario 3 - more than one active error

If there is more than one active error in the system, the DDP096 software on the DPC12 will send out DM1 in the format of BAM messages as follows. In this example the following errors are active:

- First error: SPN 0x0000A8, FMI 0x03 of warning level with one occurrence,
- Second error: SPN 0x07F183, FMI 0x02 of critical level with six occurrences,
- Third error: SPN 0x07F308, FMI 0x0B of critical level with six occurrences,
- Fourth error: SPN 0x07F30F, FMI 0x10 of warning level with eight occurrences.

Type	Msg ID	DLC	Byte0	Byte1	Byte2	Byte3	Byte4	Byte5	Byte6	Byte7
BAM	0x1CECFFzz	8	0x20	0x12	0x00	0x03	0xFF	0xCA	0xFE	0x00
			BAM	No. of bytes, LSB	No. of bytes, MSB	No of packets	Reserved	DM1 PGN Byte0	DM1 PGN Byte1	DM1 PGN Byte2
DT1	0x1CEBFFzz	8	0x01	0x10	0xFF	0xA8	0x00	0x03	0x01	0x83

Type	Msg ID	DLC	Byte0	Byte1	Byte2	Byte3	Byte4	Byte5	Byte6	Byte7
			Seq	Lamp status	Flash status	Error code 1, SPN1	Error code 1, SPN2	Error code 1, SPN3/FMI	Error code 1, OC	Error code 2, SPN1
DT2	0x1CEBFFzz	8	0x02	0xF1	0xE2	0x06	0x08	0xF3	0xEB	0x06
			Seq	Error code 2, SPN2	Error code 2, SPN3/FMI	Error code 2, OC	Error code 3, SPN1	Error code 3, SPN2	Error code 3, SPN3/FMI	Error code 3, OC
DT3	0x1CEBFFzz	8	0x03	0x0F	0xF3	0xF0	0x08	0xFF	0xFF	0xFF
			Seq	Error code 4, SPN1	Error code 4, SPN2	Error code 4, SPN3/FMI	Error code 4, OC	Reserved	Reserved	Reserved

10.4.2 DM2 PGN - previously active diagnostics trouble codes

The DM2 PGN communicates the details of the errors (DTCs) which were previously active in the DDP096 software.

The DM2 message is transmitted by the DPC12 only if it is requested by another device on the CAN bus using a request PGN message specifying PGN 0xFECB. See Request PGN section for more details.

If more than one error is active, a BAM session is used to communicate the active errors. The maximum number of errors that can be sent by BAM session is 30. If there are 29 active errors at the same time, the "Too many errors to handle by J1939" error is automatically raised, which is the 30th error in the BAM session.

10.4.2.1 Message information

When only one error was previously active a single message is sent with the following information:

Name	DM2
Priority	6
Data page	0
PDU format	0xFE
PDU specific	0xCB
Source address	DPC12 node ID (zz)
Full message ID	0x18FECBzz
DLC (length)	8
Direction	Transmitted by DPC12
Occurrence	On request

10.4.2.2 Message data

When only one error was previously active a single message is sent with the following format:

Byte no.	Bits	Encoding	Value/range	Description
0		U8	0x04: Amber lamp (info or warning error) 0x10: Red lamp (severe or critical error)	Lamp status
1		U8	0xFF	Flash status
2		U8	0x00...0xFF	LSB of SPN (suspect part number)
3		U8	0x00...0xFF	Next LSB of SPN
4	0...4		0x00...0x1F	FMI (failure mode indicator)
4	5...7		0x00...0x07	MSB of SPN
5	0...6		0x00...0x7F	Occurrence count
5	7		0x00	Conversion method
6...7			All bits set to 1	Reserved

10.4.2.3 DM2 example scenarios

The following scenarios describe the DM2 transmissions based on specific situations.

Send request for DM2

Type	Msg ID	DLC	Byte0	Byte1	Byte2
Request	0x18EAzzyy	3	0xCB	0xFE	0x00

10.4.2.3.1 Scenario 1 - single previously active error

If there is only one previously active error in the system, the DDP096 software on the DPC12 will send out the DM2 message as follows. This indicates that an error with an SPN of 0x07F30D and an FMI of 0x11 with warning severity was previously active in the system and occurred once.

Type	Msg ID	DLC	Byte0	Byte1	Byte2	Byte3	Byte4	Byte5	Byte6	Byte7
DM2	0x18FECBzz	8	0x04	0xFF	0x0D	0xF3	0xF1	0x01	0xFF	0xFF
		8	Lamp status	Flash status	SPN1	SPN2	SPN3/FMI	OC	Reserved	Reserved

10.4.2.3.2 Scenario 2 - no previously active errors

If no previously active errors are present in the system, the DDP096 software on the DPC12 will send out the DM2 message as follows:

Type	Msg ID	DLC	Byte0	Byte1	Byte2	Byte3	Byte4	Byte5	Byte6	Byte7
DM2	0x18FECBzz	8	0x00	0xFF	0x00	0x00	0x00	0x00	0xFF	0xFF
		8	Lamp status	Flash status	SPN1	SPN2	SPN3/FMI	OC	Reserved	Reserved

10.4.2.3.3 Scenario 3 - more than one previously active error

If there is more than one previously active error present in the system, the DDP096 software on the DPC12 will send out the DM2 in the format of BAM messages. In this example the following errors were previously active.

- First previously active error: SPN 0x07F183, FMI 0x02 of critical level with six occurrences.
- Second previously active error: SPN 0x07F308, FMI 0x0B of critical level with six occurrences.
- Third previously active error: SPN 0x0000A8, FMI 0x03 of warning level with one occurrence.
- Fourth previously active error: SPN 0x07F30F, FMI 0x10 of warning level with six occurrences.

Type	Msg ID	DLC	Byte0	Byte1	Byte2	Byte3	Byte4	Byte5	Byte6	Byte7
BAM	0x1CECFFzz	8	0x20	0x12	0x00	0x03	0xFF	0xCB	0xFE	0x00
			BAM	No. of bytes, LSB	No. of bytes, MSB	No. of packets	Reserved	DM2 PGN Byte0	DM2 PGN Byte1	DM2 PGN Byte2
DT1	0x1CEBFFzz	8	0x01	0x00	0xFF	0x83	0xF1	0xE2	0x06	0x08
			Seq	Lamp status	Flash status	Error code 1, SPN1	Error code 1, SPN2	Error code 1, SPN3/FMI	Error code 1, OC	Error code 2, SPN1
DT2	0x1CEBFFzz	8	0x02	0xF3	0xEB	0x06	0xA8	0x00	0x03	0x01
			Seq	Error code 2, SPN2	Error code 2, SPN3/FMI	Error code 2, OC	Error code 3, SPN1	Error code 3, SPN2	Error code 3, SPN3/FMI	Error code 3, OC
DT3	0x1CEBFFzz	8	0x03	0x0F	0xF3	0xF0	0x06	0xFF	0xFF	0xFF
			Seq	Error code 4, SPN1	Error code 4, SPN2	Error code 4, SPN3/FMI	Error code 4, OC	Reserved	Reserved	Reserved

The `lamp status` indicates the current active error status. In this example there are no currently active errors, so the value is 0x00.

10.4.2.3.4 Scenario 4 - BAM session unavailable

If there is more than one previously active error present in the system and BAM session is unavailable (may be busy with transmission of DM1/DM2) then the DDP096 software on the DPC12 will send out a busy

acknowledgment message globally as follows:

Type	Msg ID	DLC	Byte0	Byte1	Byte2	Byte3	Byte4	Byte5	Byte6	Byte7
Ack	0x18E8FFzz	8	0x02	0x00	0xFF	0xFF	0xyy	0xCB	0xFE	0x00
			BAM Busy	0x00	Reserved	Reserved	Address busy Ack	Requested PGN Byte 0	Requested PGN Byte 1	Requested PGN Byte 2

10.4.3 DM3 PGN - diagnostics data clear of previously active DTCs

The system controller, or other device on the CAN bus, can send the DM3 message to clear the occurrence counters for all errors (equivalent to setting the RESET_ERR_CNTR_CMD parameter). Each time the command is issued, up to 29 error counters are reset. Issue command three times to ensure all error counters are reset.

DM3 is sent to the DPC12 controller by sending a Request PGN with the DM3 PGN, 65228, in the requested PGN field.

On receiving the DM3 request, the DPC12 will send an Acknowledgment PGN indicating one of the following responses:

- positive acknowledgement - the action was successful.
- access denied - the action could not be processed as there was already a diagnostics data clear in progress.

10.4.3.1 Message information

See the Acknowledgment PGN section for details of the PGN sent in reply to a DM3 message.

10.4.3.2 DM3 example scenarios

The following scenarios describe the DM3 transmissions based on specific situations.

Send request for DM3

Type	Msg ID	DLC	Byte0	Byte1	Byte2
Request	0x18EAzzyy	3	0xCC	0xFE	0x00

10.4.3.2.1 Scenario 1 - positive acknowledgement of DM3

After clearing the error log history, the DPC12 will send positive acknowledgment as:

Type	Msg ID	DLC	Byte0	Byte1	Byte2	Byte3	Byte4	Byte5	Byte6	Byte7
Ack	0x18E8FFzz	8	0x00	0x00	0xFF	0xFF	0xyy	0xCC	0xFE	0x00

10.4.3.2.2 Scenario 2 - request denied, controller busy

Send a request for DM3 before the DDP096 software on the DPC12 has finished processing the previous DM3 request.

DPC12 will send busy acknowledgment as follows:

Type	Msg ID	DLC	Byte0	Byte1	Byte2	Byte3	Byte4	Byte5	Byte6	Byte7
Ack	0x18E8FFzz	8	0x02	0x00	0xFF	0xFF	0xyy	0xCC	0xFE	0x00

10.4.4 DM11 PGN - diagnostics data clear of active DTCs

The system controller, or other device on the CAN bus, can send the DM11 message to request that the DDP096 software resets its fault status and moves from the fault hold state to the disabled or active state.

This transition may not be allowed depending on the severity of previously active errors. Please see the Error handler states section for more details.

DM11 is sent to the DPC12 controller by sending a Request PGN with the DM11 PGN, 65235, in the requested PGN field.

On receiving the DM11 request, the DPC12 will send an Acknowledgment PGN indicating that either return

- positive acknowledgement - the action was successful and the fault was cleared.
- negative acknowledgement - the action was not completed as the error handler was not in the fault hold state or there was a previously active severe error.

10.4.4.1 Message information

See the Acknowledgment PGN section for details of the PGN sent in reply to a DM11 message.

10.4.4.2 DM11 example scenarios

The following scenarios describe the DM11 transmissions based on specific situations.

Send request for DM11

Type	Msg ID	DLC	Byte0	Byte1	Byte2
Request	0x18EAyyzz	3	0xD3	0xFE	0x00

10.4.4.2.1 Scenario 1 - no severe errors are present

No severe errors are present in the DPC12.

As there are no severe level errors present, DPC12 will send positive response, as follows:

Type	Msg ID	DLC	Byte0	Byte1	Byte2	Byte3	Byte4	Byte5	Byte6	Byte7
Ack	0x18E8FFzz	8	0x00	0x00	0xFF	0xFF	0xyy	0xD3	0xFE	0x00

10.4.4.2.2 Scenario 2 - severe errors are present

Severe errors are present in the DPC12.

As there are some severe errors in the system, the DPC12 will send negative response, as follows:

Type	Msg ID	DLC	Byte0	Byte1	Byte2	Byte3	Byte4	Byte5	Byte6	Byte7
Ack	0x18E8FFzz	8	0x01	0x00	0xFF	0xFF	0xyy	0xD3	0xFE	0x00

10.4.5 DM13 PGN - ignore all info and warning errors until DM13 is received

The DM13 PGN is used to transition the DPC12 from the disabled state to the active state when the SUPPORT_DM13_PGN parameter is enabled. See the Using the disabled state with DM13 section for more details on this behavior.

If parameter SUPPORT_DM13_PGN is set to 1, the DPC12 will initially enter the disabled state (unless a critical or severe error is active). When the 'Start Diagnostic DM13' message is received the DPC12 will transition to the active state. No response to the DM13 message will be sent by the DPC12.

If parameter SUPPORT_DM13_PGN is set to 0, the DPC12 will send a negative acknowledgment, see the Acknowledgment PGN section.

The DDP096 software implementation of the DM13 message is different to that described in the J1939 specification.

10.4.5.1 Message information

Name	DM13
Priority	6
Data page	0
PDU format	0xDF
PDU specific	DPC12 node ID (zz)
Source address	System controller node ID (yy)
Full message ID	0x18DFzzyy
DLC (length)	8
Direction	Received by DPC12
Occurrence	As needed

10.4.5.2 Message data

Byte No.	Bits	Encoding	Value/Range	Description
0	0...1		0: Reserved 1: Start broadcast 2: Reserved 3: No action	Network type J1939 network #1, primary vehicle network
0	2...7		Set all bits to 1	Reserved
1...7			Set all bits to 1	Reserved

DPC12 is assumed to be part of 'J1939 network #1, primary vehicle network' for the DM13 message setup.

10.4.5.3 DM13 example scenarios

The following scenarios describe the DM13 transmissions based on specific situations.

10.4.5.3.1 Scenario 1 - DM13 support enabled

SUPPORT_DM13_PGN is set to 1 and the controller has just been powered on and is in the disabled state.

The system controller sends the DM13 message to the DPC12.

Type	Msg ID	DLC	Byte0	Byte1	Byte2	Byte3	Byte4	Byte5	Byte6	Byte7
DM13	0x18DFFFyy	8	0xFD	0xFF	0xFF	0xFF	0xFF	0xFF	0xFF	0xFF

The DPC12 software will leave the disabled state. No reply message will be sent.

10.4.5.3.2 Scenario 2 - DM13 support disabled

SUPPORT_DM13_PGN is set to 0.

The system controller sends the DM13 message to the DPC12.

Type	Msg ID	DLC	Byte0	Byte1	Byte2	Byte3	Byte4	Byte5	Byte6	Byte7
DM13	0x18DFFFyy	8	0xFD	0xFF	0xFF	0xFF	0xFF	0xFF	0xFF	0xFF

As support for the DM13 message has been disabled, the DPC12 will send negative acknowledgment.

Type	Msg ID	DLC	Byte0	Byte1	Byte2	Byte3	Byte4	Byte5	Byte6	Byte7
Ack	0x18E8FFzz	8	0x01	0x00	0xFF	0xFF	0xyy	0xFF	0xDF	0x00

10.5 J1939 standard PGNs

10.5.1 Request PGN

A request PGN message is used to request a particular value be returned or action started. The message data contains only the number of the PGN requested.

10.5.1.1 Message information

Name	Request PGN
Priority	6
Data page	0
PDU format	0xEA
PDU specific	DPC12 node ID (zz)
Source address	System controller node ID (yy)
Full message ID	0x18EAzzyy
DLC (length)	3
Direction	Received by DPC12
Occurrence	As needed

10.5.1.2 Message data

Byte no.	Bits	Encoding	Value/range	Description
0...2		U24	0x00000...0x01FFFF: valid	Requested PGN

10.5.2 Acknowledgment PGN

The DDP096 software may transmit an acknowledgement frame after receiving some request messages rather than a frame containing data, for instance when there is no data response required or when a response cannot be given.

10.5.2.1 Message information

Name	Acknowledgment PGN
Priority	6
Data page	0
PDU format	0xE8
PDU specific	0xFF
Source address	DPC12 node ID (zz)
Full message ID	0x18E8FFzz
DLC (length)	8
Direction	Transmitted by DPC12
Occurrence	As needed

10.5.2.2 Message data

Byte no.	Bits	Encoding	Value/range	Description
0		U8	0x00: Positive acknowledgement 0x01: Negative acknowledgement 0x02: Access denied	Control byte
1		U8	0xFF	Group Function Value (not used)
2...3			Set all bits to 1	Reserved
4		U8	0x00...0xFF	Destination Address
5...7		U24	0x00000...0x01FFFF: valid	Requested PGN

10.5.3 Software Identification (SOFT) PGN - software identification of an electronic module

The software identification information can be read from the DPC12 controller by sending a Request PGN with the SOFT PGN, 65242, in the requested PGN field. The controller's response to a SOFT PGN request consists of 2 SPNs:

1. SPN 965, which defines how many software identification fields will be in the response
2. SPN 234, which contains the actual data of each software identification field

The DPC12 controller responds with five software identification fields:

1. Application Program Identity
2. Application Program Version
3. Application Program Timestamp
4. Controller Boot Version
5. Controller FPGA Revision

An example of the full response in ASCII characters is "DDP A1 AA*2.7.1*2022-02-14 09:41:00*690*142820*". The '*' character delimits each software identification field, with one added at the end as well.

10.5.3.1 Message information

Name	SOFT PGN
Priority	6
Data page	0
PDU format	0xFE
PDU specific	0xDA
Source address	DPC12 node ID (zz)
Full message ID	0x18FEDAzz
DLC (length)	Variable
Direction	Transmitted by DPC12
Occurrence	On request

10.5.3.2 Message data

The SOFT PGN response will be transmitted by the controller as a BAM, because the message data is larger than 8 bytes.

Below are example contents of the TP.DT message for the SOFT PGN response. The data contained is as in the example response above.

Type	Msg ID	DLC	Byte0	Byte1	Byte2	Byte3	Byte4	Byte5	Byte6	Byte7
BAM	0x1CECFFzz	8	0x20	0x30	0x00	0x07	0xFF	0xDA	0xFE	0x00
			BAM	No. of bytes, LSB	No. of bytes, MSB	No. of packets	Reserved	SOFT PGN Byte0	SOFT PGN Byte1	SOFT PGN Byte2
DT1	0x1CEBFFzz	8	0x01	0x05	0x44	0x44	0x50	0x20	0x41	0x31
			Seq	No. of fields	'D'	'D'	'P'	' '	'A'	'1'
DT2	0x1CEBFFzz	8	0x02	0x20	0x41	0x41	0x2A	0x32	0x2E	0x37
			Seq	' '	'A'	'A'	'*'	'2'	'.'	'7'
DT3	0x1CEBFFzz	8	0x03	0x2E	0x31	0x2A	0x32	0x30	0x32	0x32
			Seq	'.'	'1'	'*'	'2'	'0'	'2'	'2'
DT4	0x1CEBFFzz	8	0x04	0x2D	0x30	0x32	0x2D	0x31	0x34	0x20
			Seq	'-'	'0'	'2'	'-'	'1'	'4'	' '
DT5	0x1CEBFFzz	8	0x05	0x30	0x39	0x3A	0x34	0x31	0x3A	0x30
			Seq	'0'	'9'	':'	'4'	'1'	':'	'0'
DT6	0x1CEBFFzz	8	0x06	0x30	0x2A	0x36	0x39	0x30	0x2A	0x31
			Seq	'0'	'*'	'6'	'9'	'0'	'*'	'1'
DT7	0x1CEBFFzz	8	0x07	0x34	0x32	0x38	0x32	0x30	0x2A	0xFF
			Seq	'4'	'2'	'8'	'2'	'0'	'*'	Reserved

10.5.4 ECU Identification (ECUID) PGN - Message for reporting identification and information about the physical ECU and its hardware

The ECU identification information can be read from the DPC12 controller by sending a Request PGN with the ECUID PGN, 64965, in the requested PGN field. The controller's response to an ECUID PGN request consists of six SPNs:

1. SPN 2901, ECU Part Number
2. SPN 2902, ECU Serial Number
3. SPN 2903, ECU Location
4. SPN 2904, ECU Type
5. SPN 4304, ECU Manufacturer Name
6. SPN 6714, ECU Hardware ID

An example of the full response in ASCII characters is "11282002-A*746358502252**DPC12*Danfoss**". The '*' character is used to delimit each ECU identification field, with one added at the end as well.

The ECU Location and ECU Hardware ID fields are purposely left blank as no relevant information is available.

10.5.4.1 Message information

Name	ECUID PGN
Priority	6
Data page	0
PDU format	0xFD
PDU specific	0xC5
Source address	DPC12 node ID (zz)
Full message ID	0x18FDC5zz
DLC (length)	Variable
Direction	Transmitted by DPC12
Occurrence	On request

10.5.4.2 Message data

The ECUID PGN response will be transmitted by the controller as a BAM, because the message data is larger than 8 bytes.

Below are example contents of the TP.DT message for the ECUID PGN response.

Type	Msg ID	DLC	Byte0	Byte1	Byte2	Byte3	Byte4	Byte5	Byte6	Byte7
BAM	0x1CECFFzz	8	0x20	0x2F	0x00	0x07	0xFF	0xC5	0xFD	0x00
			BAM	No. of bytes, LSB	No. of bytes, MSB	No. of packets	Reserved	ECUID PGN Byte0	ECUID PGN Byte1	ECUID PGN Byte2
DT1	0x1CEBFFzz	8	0x01	0x20	0x20	0x20	0x20	0x31	0x31	0x32
			Seq	' '	' '	' '	' '	'1'	'1'	'2'
DT2	0x1CEBFFzz	8	0x02	0x38	0x32	0x30	0x30	0x32	0x2D	0x41
			Seq	'8'	'2'	'0'	'0'	'2'	'-'	'A'
DT3	0x1CEBFFzz	8	0x03	0x20	0x20	0x20	0x2A	0x37	0x34	0x36
			Seq	' '	' '	' '	'*'	'7'	'4'	'6'
DT4	0x1CEBFFzz	8	0x04	0x33	0x35	0x38	0x35	0x30	0x32	0x32
			Seq	'3'	'5'	'8'	'5'	'0'	'2'	'2'
DT5	0x1CEBFFzz	8	0x05	0x35	0x32	0x2A	0x2A	0x44	0x50	0x43
			Seq	'5'	'2'	'*'	'*'	'D'	'P'	'C'
DT6	0x1CEBFFzz	8	0x06	0x31	0x32	0x2A	0x44	0x61	0x6E	0x66
			Seq	'1'	'2'	'*'	'D'	'a'	'n'	'f'
DT7	0x1CEBFFzz	8	0x07	0x6F	0x73	0x73	0x2A	0x2A	0xFF	0xFF
			Seq	'o'	's'	's'	'*'	'*'	Reserved	Reserved

10.6 Manufacturer specific PGNs

The DDP096 software uses several manufacturer specific messages to control and report Digital Displacement® Pump functionality. These messages use the J1939 proprietary PGNs which can operate alongside all standardized J1939 PGNs. The messages used are designed to operate alongside other Danfoss products, however equipment manufactured by other manufacturers may use conflicting definitions for the proprietary PGNs. Each manufacturer specific PGN is listed in the following sections.

⚠ Warning

Danfoss manufacturer specific PGNs may conflict with other devices on the CAN bus. The system designer must check for compatibility.

10.6.1 Control PGNs

The DDP096 software can receive control messages from a system controller on the CAN bus to allow the hydraulic outputs to be controlled dynamically. Whether the data in the message is used or not depends on the value of the source parameter corresponding to the control reference or limit in the message. See Control

configuration section for more details.

If any data in the message is used, then the system controller must ensure the message is received regularly by the DPC12 controller, otherwise a timeout error will be raised. Conversely, when no elements in a message are used, the message does not need to be sent by the system controller. See Errors section for more details.

If an element in a message is not used, then a special value indicating explicitly that no data is contained should be sent by the controller. This byte sequence, listed in the message data tables below as "not used/not requested", is defined in the J1939 standard.

10.6.1.1 Pump setup A

The pump setup A message allows the system controller to control whole pump features in the software. The message must be sent by the system controller if the pumping enable source or service configuration index source are set to J1939.

10.6.1.1.1 Message information

Name	Pump setup A
Priority	3
Data page	0
PDU format	0xEF
PDU specific	DPC12 node ID (zz)
Source address	System controller node ID (yy)
Full message ID	0x0CEFzzyy
DLC (length)	8
Direction	Received by DPC12
Occurrence	Repeated when PUMPING_ENABLE_SRC or SERV_CONF_INDEX_SRC set to J1939. Timeout 300 ms.

10.6.1.1.2 Message data

Byte no.	Bits	Encoding	Value/range	Description
0...1			0xDD00	Message ID
2...3		SAEbm16	0x0000...0x00FF: Enable bitmap 0x0100...0xFDFF: Reserved 0xFExx: Error indicator 0xFFxx: Not used/not requested	Pumping enable per service. Service 1 by bit 0, Service 2 by bit 1, Service 3 by bit 2. Set other bits to 0. Also see PUMPING_ENABLE parameter.
4		SAEbs08	0...2: Index for pumplet combination 4...253: Reserved 0xFE: Error indicator 0xFF: Not used/not requested	Service configuration index, see SERV_CONF_INDEX parameter
5...7			All bits set to 1	Reserved

10.6.1.2 Displacement reference A

The displacement reference A message allows the displacement reference to several services to be sent in displacement mode. The message must be sent by the system controller if the DDP096 software is set up for displacement control over J1939 on either service (see "Occurrence" in the table below).

10.6.1.2.1 Message information

Name	Displacement reference A
Priority	3
Data page	0
PDU format	0xEF
PDU specific	DPC12 node ID (zz)
Source address	System controller node ID (yy)
Full message ID	0x0CEFzzyy
DLC (length)	8
Direction	Received by DPC12
Occurrence	Repeated when either CONTROL_MODE_S1, CONTROL_MODE_S2 or CONTROL_MODE_S3 are displacement control and its source (CONTROL_REF_SRC_S1, CONTROL_REF_SRC_S2 or CONTROL_REF_SRC_S3) is set to J1939. Timeout 300 ms.

10.6.1.2.2 Message data

Byte no.	Bits	Encoding	Value/range	Description
0...1			0xDD10	Message ID
2...3		SAEpc11	0%...100%: Valid 0xFExx: Error indicator 0xFFxx: Not used/not requested	Displacement reference for service 1, see DISP_REF_S1 parameter
4...5		SAEpc11	0%...100%: Valid 0xFExx: Error indicator 0xFFxx: Not used/not requested	Displacement reference for service 2, see DISP_REF_S2 parameter
6...7		SAEpc11	0%...100%: Valid 0xFExx: Error indicator 0xFFxx: Not used/not requested	Displacement reference for service 3, see DISP_REF_S3 parameter

10.6.1.3 Pressure reference A

The pressure reference A message allows the pressure reference to several services to be sent in pressure control mode. The message must be sent by the system controller if the DDP096 software is set up for pressure control over J1939 on either service (see "Occurrence" in the table below).

10.6.1.3.1 Message information

Name	Pressure reference A
Priority	3
Data page	0
PDU format	0xEF
PDU specific	DPC12 node ID (zz)
Source address	System controller node ID (yy)
Full message ID	0x0CEFzzyy
DLC (length)	8
Direction	Received by DPC12
Occurrence	Repeated when either CONTROL_MODE_S1, CONTROL_MODE_S2 or CONTROL_MODE_S3 are pressure control and its source (CONTROL_REF_SRC_S1, CONTROL_REF_SRC_S2 or CONTROL_REF_SRC_S3) is set to J1939. Timeout 300 ms.

10.6.1.3.2 Message data

Byte no.	Bits	Encoding	Value/range	Description
0...1			0xDD13	Message ID
2...3		SAEpr08	0...42000 kPa (420 bar): Valid 0xFExx: Error indicator 0xFFxx: Not used/not requested	Pressure reference for service 1, see PRESS_REF_S1 parameter
4...5		SAEpr08	0...42000 kPa (420 bar): Valid 0xFExx: Error indicator 0xFFxx: Not used/not requested	Pressure reference for service 2, see PRESS_REF_S2 parameter
6...7		SAEpr08	0...42000 kPa (420 bar): Valid 0xFExx: Error indicator 0xFFxx: Not used/not requested	Pressure reference for service 3, see PRESS_REF_S3 parameter

10.6.1.4 Pressure margin reference A

The pressure margin reference A message allows the pressure margin reference to several services to be sent in load-sense mode. The message must be sent by the system controller if the DDP096 software is set up for load-sense control over J1939 on either service (see "Occurrence" in the table below).

10.6.1.4.1 Message information

Name	Pressure margin reference A
Priority	3
Data page	0
PDU format	0xEF
PDU specific	DPC12 node ID (zz)
Source address	System controller node ID (yy)
Full message ID	0x0CEFzzyy
DLC (length)	8
Direction	Received by DPC12
Occurrence	Repeated when either CONTROL_MODE_S1, CONTROL_MODE_S2 or CONTROL_MODE_S3 are load-sense and its source (CONTROL_REF_SRC_S1, CONTROL_REF_SRC_S2 or CONTROL_REF_SRC_S3) is set to J1939. Timeout 300 ms.

10.6.1.4.2 Message data

Byte no.	Bits	Encoding	Value/range	Description
0...1			0xDD16	Message ID
2...3		SAEpr08	0...10000 kPa (100 bar): Valid 0xFExx: Error indicator 0xFFxx: Not used/not requested	Pressure margin reference for service 1, see PRESS_MARGIN_REF_S1 parameter
4...5		SAEpr08	0...10000 kPa (100 bar): Valid 0xFExx: Error indicator 0xFFxx: Not used/not requested	Pressure margin reference for service 2, see PRESS_MARGIN_REF_S2 parameter
6...7		SAEpr08	0...10000 kPa (100 bar): Valid 0xFExx: Error indicator 0xFFxx: Not used/not requested	Pressure margin reference for service 3, see PRESS_MARGIN_REF_S3 parameter

10.6.1.5 Torque limit A

The torque limit A message allows the torque limit to several services to be sent. The message must be sent by the system controller if one of the torque limit source parameters is set to J1939.

10.6.1.5.1 Message information

Name	Torque limit A
Priority	3
Data page	0
PDU format	0xEF
PDU specific	DPC12 node ID (zz)
Source address	System controller node ID (yy)
Full message ID	0x0CEFzzyy
DLC (length)	8
Direction	Received by DPC12
Occurrence	Repeated when either TRQ_LIM_SRC_S1, TRQ_LIM_SRC_S2 or TRQ_LIM_SRC_S3 are set to J1939. Timeout 300 ms.

10.6.1.5.2 Message data

Byte no.	Bits	Encoding	Value/range	Description
0...1			0xDD40	Message ID
2...3		DDtq01	0...1500 Nm: Valid 0xFExx: Error indicator 0xFFxx: Not used/not requested	Torque limit for service 1, see TRQ_LIM_S1 parameter
4...5		DDtq01	0...1500 Nm: Valid 0xFExx: Error indicator 0xFFxx: Not used/not requested	Torque limit for service 2, see TRQ_LIM_S2 parameter
6...7		DDtq01	0...1500 Nm: Valid 0xFExx: Error indicator 0xFFxx: Not used/not requested	Torque limit for service 3, see TRQ_LIM_S3 parameter

10.6.1.6 Flow limit A

The flow limit A message allows the flow limit to several services to be sent. The message must be sent by the system controller if one of the flow limit source parameters is set to J1939.

10.6.1.6.1 Message information

Name	Flow limit A
Priority	3
Data page	0
PDU format	0xEF
PDU specific	DPC12 node ID (zz)
Source address	System controller node ID (yy)
Full message ID	0x0CEFzzyy
DLC (length)	8
Direction	Received by DPC12
Occurrence	Repeated when either FLOW_LIM_SRC_S1, FLOW_LIM_SRC_S2 or FLOW_LIM_SRC_S3 are set to J1939. Timeout 300 ms.

10.6.1.6.2 Message data

Byte no.	Bits	Encoding	Value/range	Description
0...1			0xDD43	Message ID
2...3		DDfl02	0...300 L/min: Valid 0xFExx: Error indicator 0xFFxx: Not used/not requested	Flow limit for service 1, see FLOW_LIM_S1 parameter
4...5		DDfl02	0...300 L/min: Valid 0xFExx: Error indicator 0xFFxx: Not used/not requested	Flow limit for service 2, see FLOW_LIM_S2 parameter
6...7		DDfl02	0...300 L/min: Valid 0xFExx: Error indicator 0xFFxx: Not used/not requested	Flow limit for service 3, see FLOW_LIM_S3 parameter

10.6.1.7 Power limit A

The power limit A message allows the power limit to several services to be sent. The message must be sent by the system controller if one of the power limit source parameters is set to J1939.

10.6.1.7.1 Message information

Name	Power limit A
Priority	3
Data page	0
PDU format	0xEF
PDU specific	DPC12 node ID (zz)
Source address	System controller node ID (yy)
Full message ID	0x0CEFzzyy
DLC (length)	8
Direction	Received by DPC12
Occurrence	Repeated when either PWR_LIM_SRC_S1, PWR_LIM_SRC_S2 or PWR_LIM_SRC_S3 are set to J1939. Timeout 300 ms.

10.6.1.7.2 Message data

Byte no.	Bits	Encoding	Value/range	Description
0...1			0xDD46	Message ID
2...3		SAEpw08	0...500 kW: Valid 0xFExx: Error indicator 0xFFxx: Not used/not requested	Torque limit for service 1, see PWR_LIM_S1 parameter
4...5		SAEpw08	0...500 kW: Valid 0xFExx: Error indicator 0xFFxx: Not used/not requested	Torque limit for service 2, see PWR_LIM_S2 parameter
6...7		SAEpw08	0...500 kW: Valid 0xFExx: Error indicator 0xFFxx: Not used/not requested	Torque limit for service 3, see PWR_LIM_S3 parameter

10.6.2 Status PGNs

The DDP096 software transmits several messages to indicate the status of the software and connected pump during operation. These messages may be used by a system controller for feedback on DDP096 pump operation, logged with a data acquisition system or inspected manually by the user.

10.6.2.1 Pump info A

The pump info A message contains information relating to the overall state of the DDP096 software and pump.

10.6.2.1.1 Message information

Name	Pump info A
Priority	3
Data page	0
PDU format	0xFF
PDU specific	0xDD (message ID MSB)
Source address	DPC12 node ID (zz)
Full message ID	0x0CFFDDzz
DLC (length)	8
Direction	Transmitted by DPC12
Occurrence	Repeated every 100 ms

10.6.2.1.2 Message data

Byte no.	Bits	Encoding	Value/range	Description
0			0x70	Message ID (LSB)
1			All bits set to 1	Reserved
2...3		SAEvr07	-3500...3500 rpm: Valid 0xFExx: Error indicator 0xFFxx: Not used/not requested	Actual shaft speed, see ACTL_SHAFT_SPD parameter
4		SAEtp01	-40...150°C: Valid 0xFE: Error indicator 0xFF: Not used/not requested	Actual pump temperature, see ACTL_PUMP_TEMP parameter
5			All bits set to 1	Reserved
6	0...3	SAEbs04	0...4: Valid 0xFE: Error indicator 0xFF: Not used/not requested	Device state, see DEVICE_STATE parameter
6	4...7	SAEbs04	0...2: Valid 0xFE: Error indicator 0xFF: Not used/not requested	Device mode, see DEVICE_MODE parameter
7			All bits set to 1	Reserved

10.6.2.2 Service 1 status

The service 1 status message contains information relating to the current operating conditions of service 1 of the DDP096 software and pump.

10.6.2.2.1 Message information

Name	Service 1 status
Priority	3
Data page	0
PDU format	0xFF
PDU specific	0xDD (message ID MSB)
Source address	DPC12 node ID (zz)
Full message ID	0x0CFFDDzz
DLC (length)	8
Direction	Transmitted by DPC12
Occurrence	Repeated every 10 ms

10.6.2.2.2 Message data

Byte no.	Bits	Encoding	Value/range	Description
0			0x80	Message ID (LSB)
1			All bits set to 1	Reserved
2...3		SAEpc11	0...100%: Valid 0xFExx: Error indicator 0xFFxx: Not used/not requested	Actual service displacement, see ACTL_DISP_S1 parameter
4...5		SAEpr08	0...60000 kPa (600 bar): Valid 0xFExx: Error indicator 0xFFxx: Not used/not requested	Actual service pressure, see ACTL_PRESS_S1 parameter
6...7		SAEpr08	0...100000 kPa (1000 bar): Valid 0xFExx: Error indicator 0xFFxx: Not used/not requested	Actual service LS pressure, see ACTL_LS_PRESS_S1 parameter

10.6.2.3 Service 2 status

The service 2 status message contains information relating to the current operating conditions of service 2 of the DDP096 software and pump.

10.6.2.3.1 Message information

Name	Service 2 status
Priority	3
Data page	0
PDU format	0xFF
PDU specific	0xDD (message ID MSB)
Source address	DPC12 node ID (zz)
Full message ID	0x0CFFDDzz
DLC (length)	8
Direction	Transmitted by DPC12
Occurrence	Repeated every 10 ms in AB and AC software variants. Not used in AA software variant.

10.6.2.3.2 Message data

Byte no.	Bits	Encoding	Value/range	Description
0			0x81	Message ID (LSB)
1			All bits set to 1	Reserved
2...3		SAEpc11	0...100%: Valid 0xFExx: Error indicator 0xFFxx: Not used/not requested	Actual service displacement, see ACTL_DISP_S2 parameter
4...5		SAEpr08	0...60000 kPa (600 bar): Valid 0xFExx: Error indicator 0xFFxx: Not used/not requested	Actual service pressure, see ACTL_PRESS_S2 parameter
6...7		SAEpr08	0...100000 kPa (1000 bar): Valid 0xFExx: Error indicator 0xFFxx: Not used/not requested	Actual service LS pressure, see ACTL_LS_PRESS_S2 parameter

10.6.2.4 Service 3 status

The service 3 status message contains information relating to the current operating conditions of service 3 of the DDP096 software and pump.

10.6.2.4.1 Message information

Name	Service 3 status
Priority	3
Data page	0
PDU format	0xFF
PDU specific	0xDD (message ID MSB)
Source address	DPC12 node ID (zz)
Full message ID	0x0CFFDDzz
DLC (length)	8
Direction	Transmitted by DPC12
Occurrence	Repeated every 10 ms in AC software variant. Not used in AA and AB software variants.

10.6.2.4.2 Message data

Byte no.	Bits	Encoding	Value/range	Description
0			0x82	Message ID (LSB)
1			All bits set to 1	Reserved
2...3		SAEpc11	0...100%: Valid 0xFExx: Error indicator 0xFFxx: Not used/not requested	Actual service displacement, see ACTL_DISP_S3 parameter
4...5		SAEpr08	0...60000 kPa (600 bar): Valid 0xFExx: Error indicator 0xFFxx: Not used/not requested	Actual service pressure, see ACTL_PRESS_S3 parameter
6...7		SAEpr08	0...100000 kPa (1000 bar): Valid 0xFExx: Error indicator 0xFFxx: Not used/not requested	Actual service LS pressure, see ACTL_LS_PRESS_S3 parameter

11 Updating software on the controller

The software on the DPC12 controller can be updated in the field by using the PLUS+1® Service Tool. Please refer to the PLUS+1® Service Tool user manual for instructions on this process. In Service Tool version 2022.2 this is accessed from within the "Help" menu and instructions are contained within the "Downloading the application" of the user manual.

There are two steps to downloading the DDP096 software

1. Install the diagnostic data file (`.plg` file) for the software build in the tool. In PLUS+1® Service Tool version 2022.2 this is completed using the "Install Diagnostic Data..." in the "Option" menu.
2. Download the application software to DPC12 controller. In PLUS+1® Service Tool version 2022.2 this is completed using the "File Download..." in the "System" menu.

If the matching diagnostic data file is not installed in PLUS+1® Service Tool before the application software is downloaded, an error "No diagnostic file installed" will be shown. Install the diagnostic data file to clear the error.

Please read the relevant release notes before updating the software. Systems should be recommissioned after updating to ensure the DDP096 pump functions as desired.

The parameters on the DPC12 controller should be backed up before upgrading the software. If the software is upgraded to a version with new parameters the non-volatile memory format may be incompatible and the parameters reset to their default value. Please check all parameters after the update has been completed.

⚠ Warning

Parameters may be reset to default during a software update.

Contact your Danfoss representative for assistance when updating if required.

12 References

Digital Displacement® Pump Gen 1 DDP096 and DPC12 Technical Information
- https://assets.danfoss.com/documents/184429/BC306384089197en-000201.pdf

PLUS+1® Service Tool download
- https://www.danfoss.com/en/products/dps/software/software-and-tools/plus1-software/#tab-downloads

SAE J1939 Digital Annex
- https://www.sae.org/standards/content/j1939da_202103/

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