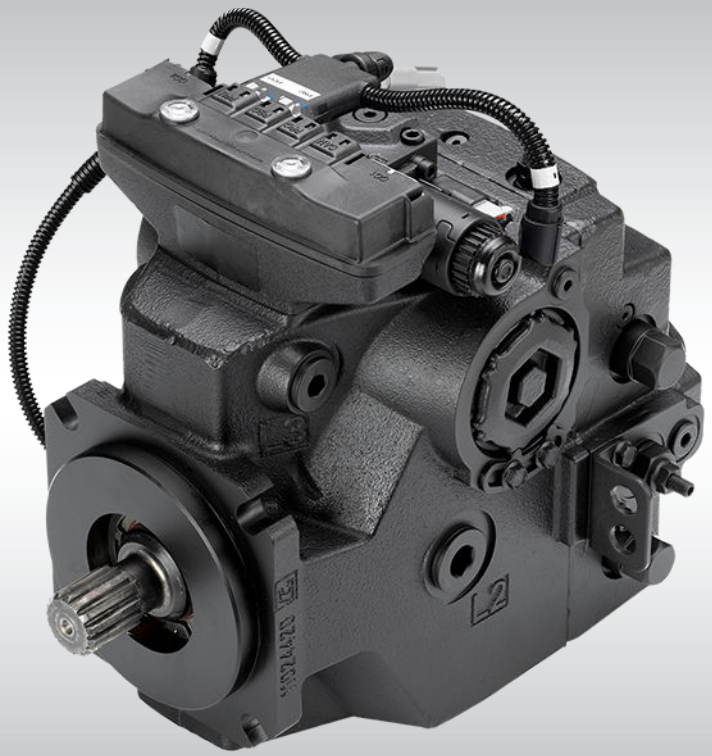
MAKING MODERN LIVING POSSIBLE

Technical Information

H1 Automative Control
for Single Axial Piston Pumps Size 045-165 cm³



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Revision history

Table of revisions

Date	Changed	Rev
May 2014	Size 165 added	DA
Feb 2014	Layout in DITA CMS	CA
Oct 2013	Converted to Danfoss layout	BA
Jan 2013	All frame sizes into one document	AA

Contents

Contents

General description

General description, electric and clectronics

Automotive-Control AC-1 and AC-2, system description

The Automotive-Control is designed to control a single-path hydrostatic transmission system consisting of one pump and one motor.

The hydrostatic pump is equipped with 2 proportional valves.

The Automotive Control is divided into 2 systems, AC-1 and AC-2. AC-2 is an extension of AC-1 that features an integrated pump swash plate angle sensor and software enabled functions such as Swash Plate Control and Flow Limiter.

The AC is optimized for use with a hydrostatic motor equipped with Pressure Control Override (PCOR) or Proportional (PROP) valve to control pressure or motor displacement. Additionally a Brake Pressure Defeat (BPD) digital control valve can override the hydraulic pressure control during vehicle decelerating.

Parking Brake Valve, Reverse Motion buzzer, Forward/Reverse-Lamp-Indicator, a Retarder valve and a Stabilizer-Valve can be controlled by additional digital outputs. All functions may not be available simultaneously.

The H1 AC can read several analog, digital, and frequency signals representing operator input, system demands, and machine status inputs.

The CAN Comunication Interface is used for diagnosis purposes and for information exchanging with other controllers such as engines, other Danfoss Power Solutions - or customer-controllers.

Automotive Control (AC-1 and AC-2), advanced functions

The Automotive Control commands the basic vehicle driving behavior and performance (i.e. acceleration, deceleration, and vehicle speed). The operator selects the driving mode, driving direction, and basic transmission set point command via throttle or Creep/Drive pedal. An additional input, the inch pedal command, can be used to override the basic transmission command.

A number of advanced features can be independantly activated and configured depending on the installed Application Software package.

Below is a list of the primary advanced functions:

- Engine and motor over-speed protection
- Engine anti stall
- Constant speed control
- ECO fuel saving mode
- Vehicle speed limitation and flow limiter
- Intelligent operator presence detection
- Electronic swash plate control
- Temperature compensation and overheat-protection
- Maximum motor torque at vehicle start
- Engine speed dependend retarder control
- Cruise Control in Work Mode

Mode types

Automotive Control (AC-1 and AC-2) hydrostatic propel methods

The application software provides 3 different hydrostatic propel methods, defined as mode types, which can be used individually.

General description

- **"Automotive"** — Load dependent (torque controlled) driving behaviour. Setpoint for the drive curve is the engine rpm.
- **"Non-Automotive"** — Load independent (speed controlled) driving mode. The setpoint for the drive curve is a Joystick or pedal signal, independent of the engine rpm. The best performance will achived with a AC-2 Swash Plate Angle Sensor.
- **"Creep-Automotive"** — Load dependent (torque controlled) driving behaviour (like Automotive). Setpoint for the drive curve is the engine rpm. The setpoint can be reduced by the creep potentiometer if a high engine rpm in combination with low vehicle speed is needed.

Automotive and Creep-Automotive mode types are primarily intended for Wheel Loader and Telescopic Handler applications. The Non-Automotive mode type is primarily intended for Sweeper, Forestry, and Forklift applications.

All mode types are available as part of the basic application (hardware and software) and can be independently configured for performance utilizing advanced software and hardware settings.

Each selectable system mode can be configured as one of the 3 mode types (hydrostatic propel methods) below:

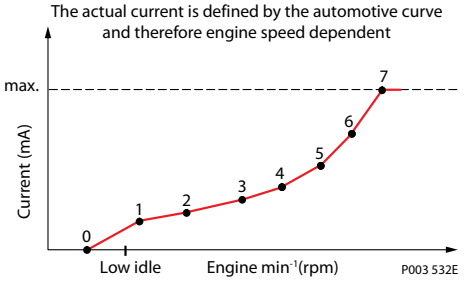
- Automotive Mode
- Non-Automotive Mode
- Creep-Automotive Mode; (combination of Automotive and Non-Automotive)

Mode-Type: Automotive mode

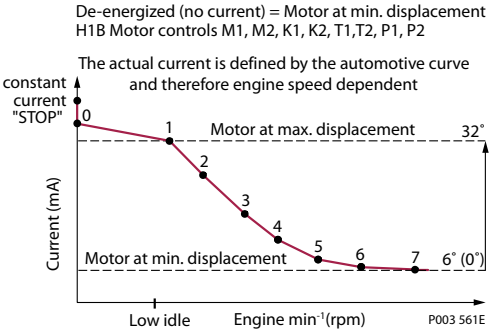
In Automotive Mode the current to the proportional valves is directly controlled by the measured engine RPM. The current is independently parameter configurable for pump and motor in each mode. The Automotive Mode provides good anti-stall behavior due to the load dependant control.

The profile curve (points 0-7) of the Automotive Mode drive curve are set according to the available torque characteristics of the engine, accounting for additional auxiliary power.

Pump drive curve

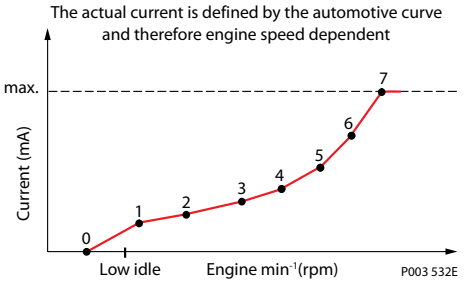


Motor drive curve

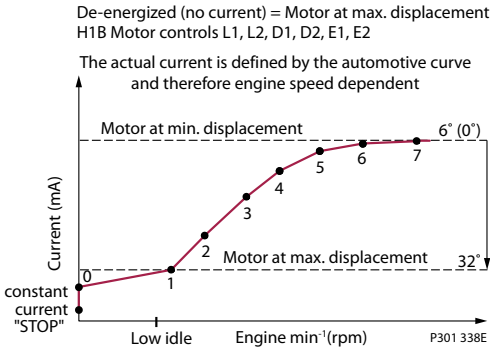


General description

Pump drive curve



Motor drive curve

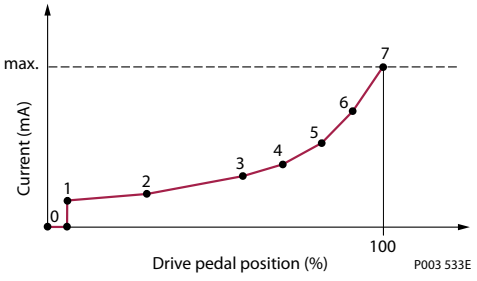


Mode-Type: Non-Automotive mode

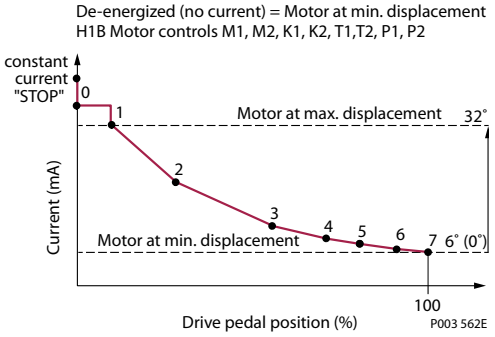
The Non-Automotive Mode uses an analog input signal from the drive pedal to command vehicle speed. The pump and motor valve current are controlled by the system mode profile and are independent of the engine rpm.

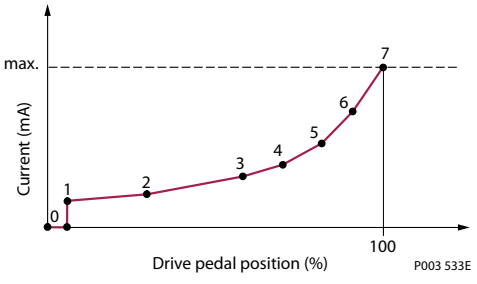
The best performance will achived with a AC-2 Swash Plate Angle Sensor and the cruise control constant speed function.

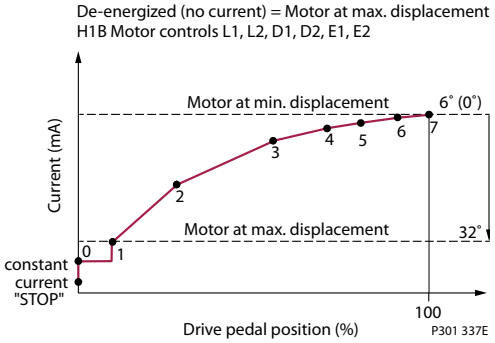
Pump drive curve



Motor drive curve







Mode-Type: Creep-Automotive Mode

Creep-Automotive Mode is a combination of both Automotive and Non-Automotive Mode. Creep Automotive Mode uses an analog input signal (Drive/Creep Potentiometer) to control the pump valve current. The available pump valve current is limited by the automotive curve dedicated to this mode type. The actual current to the pump valve is the product of the actual engine RPM, the defined automotive curve, and the actual percentage of Drive/Creep Potentiometer input. Creep-Automotive is

General description

active above a user defined “Creep Start RPM”, below this RPM the propel system behaves like Automotive-Mode. The motor valve current follows the automotive curve.

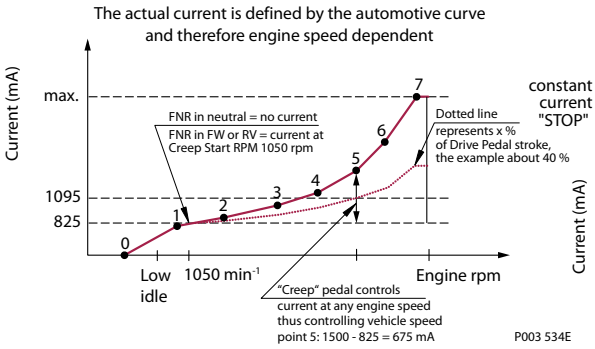
Actual engine RPM = 1800 min-1 => $I_{Automotive\text{-}Curve}$ = 1500 mA;

Actual Pedal value = 40%;

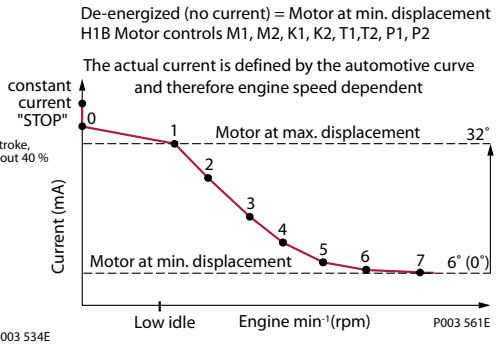
Creep Start RPM = 1050 min-1 => $I_{CreepStart}$ = 825 mA;

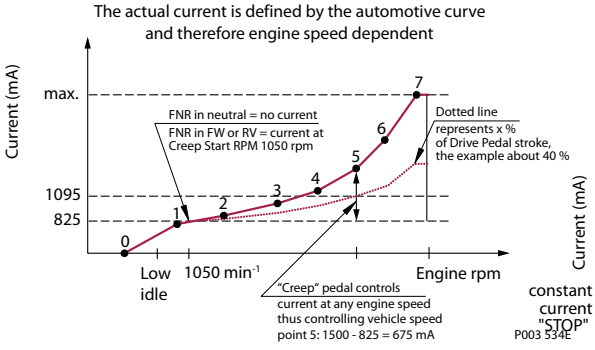
$I_{Valve} = [(1500\text{-}I_{CreepStart}) * 40 / 100] + I_{CreepStart}$ = 1095 mA

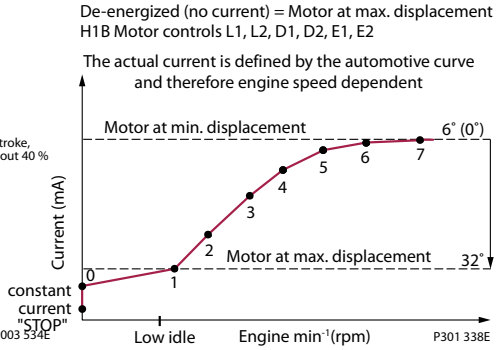
Pump drive curve



Motor drive curve







General description

System modes and selection

The application simultaneously supports up to 4 system modes. The system modes define the basic characteristic of the transmission and are operator selectable via 2 digital inputs: Mode Switch A and Mode Switch B. Each of the four system modes can be optimized for driving behavior through independent drive curves with individual pump and motor ramping.

Each of the four system modes can be configured as any one of the mode types (propel methods).

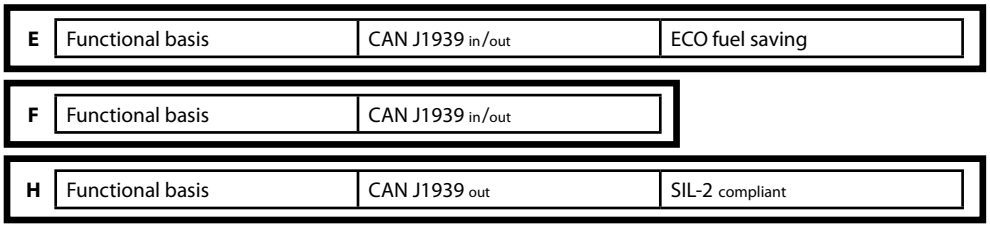
The following table describes the relationship between the digital input mode switches and the resulting system modes.

Modes and selection

		System mode			
		Mode 1	**Mode 2**	**Mode 3**	**Mode 4**
Mode Switch A		Low	Low	High	High
Mode Switch B	Nominal	Low	High	Low	High
	Redundant	High	Low	High	Low

Functional option packages

3 functional option packages are avaliable for all AC-1 pumps



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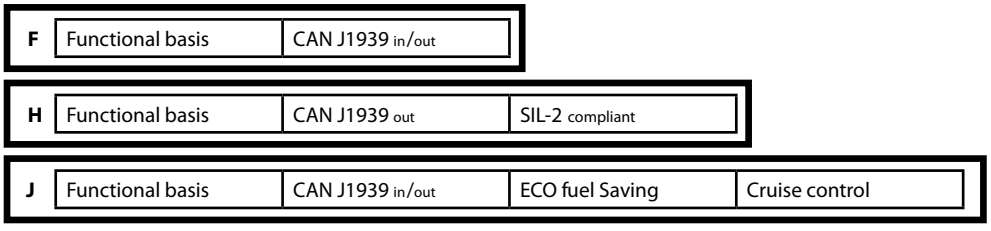
3 functional option packages are avaliable for all AC-2 pumps with a swach plate angle sensor



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Functions

Basic functions

Basic Functions		Requirements
1	**Inching Function** The inch function allows the operator to reduce the vehicle speed, stop the machine or keep the vehicle speed low while raising the engine speed to meet auxiliary flow demands.	-
2	**Drive/Creep Pedal** The drive pedal allows the operator to command the vehicle speed through pump and motor displacement setpoint. In addition a CAN controlled engine can be commanded. The Creep potentiometer function will keep the vehicle speed low while raising the engine speed to meet auxiliary flow demands.	-
2a	**Joystick or Rocker Pedal** A Joystick or Rocker Pedal will combine the function of the drive pedal with FNR direction switch.	Not available in special settings D3E, D4E, D5J or D6J
3	**4 Selectable System-Modes** The application supports 4 configurable System Modes which are selectable with digital inputs Mode Switch A and Mode Switch B. Each System Mode can be individually configured through Mode Type (Automotive, Creep-Automotive, Non-Automotive) and all advanced functions (e.g. CSD, Antistall, Overspeed Protection, etc.).	-
4	**Independent Pump/Motor-Profiling & Ramping** The pump and motor curves can both be independently configured for the forward and reverse driving direction in each of the four modes. The software application facilitates individual command profiles.	-
5	**Configurable System-Mode- & Direction-Change** This function allows configuration of an application specific System Mode transition. The System Mode change conditions can be dependent on multiple factors including actual FNR Direction, Drive Pedal Input, and Ground Speed. The vehicle driving direction change can be configured on vehicle speed and/or measured pump swashplate angle dependency.	-
6	**Pump Speed Sensor** The pre-installed pump speed sensor is connected to calculate the pump/engine rpm. The calculated engine rpm is the setpoint for the automotive drive curve.	-
7	**Hydro-Motor Speed Sensor** A hydro-motor speed sensor can be connected to calculate the vehicle speed utilizing the configured final drive ratio & wheel diameter. The calculated vehicle speed enables advanced functions such as constant speed drive and vehicle speed limitation.	-
8	**Proportional Pump Displacement Control** The proportional pump displacement is directly controlled by the measured engine rpm. (Automotive Mode = NFPE). For each of the four System Modes two independent profile curves for forward & reverse are available.	-
9	**Load Independent Pump Displacement Control (Option AC2)** The load independent pump displacement control maintains commanded swash plate position independent of load (Non-Automotive, similar to EDC behavior) using electronic feedback from the pump swash plate angle sensor. The function can be enabled individually for each of the four System Modes. Two independent profile curves for forward & reverse are available.	Control: B7 or C3
10	**Engine Anti-Stall Protection** The Engine Anti-Stall prevents the engine from being stalled due to overload through the transmission system. If the engine is drooped, the engine anti-stall function will reduce the pump command to reduce the engine load and prevent the engine from stalling. The engine anti-stall can be individually enabled for each system mode and is configurable at: • A fixed engine rpm setpoint or • A variable engine rpm, commanded by the drive pedal (needs a CAN controlled engine)	-

Functions

Basic Functions		Requirements
11	**Hydro-Motor Displacement Control** Variable displacement and 2-Position motors can be controlled directly. The hydro-motor command can be defined by a constant value or a profile curve output, individually for each of the four System Modes and driving direction.	-
12	**Hydro-Motor Brake Pressure Defeat (BPD) Control** The Motor BPD Control is used in combination with a pressure controlled (PCOR) hydro-motor control. It prevents the activation of the internal motor control pressure compensator (PCOR) during deceleration events. The Motor BPD Control is activated by the pump command (System State Change) or the measured vehicle driving direction (needs a hydro-motor speed & direction sensor)	hydro-motor speed & direction sensor
13	**Maximum Hydro-Motor Torque at Low Vehicle Speed** This function will command the hydro-motor to max displacement during low vehicle speed to provide the maximum available torque. If the defined vehicle speed is reached, the hydro-motor will follow the original drive curve. A hydro-motor or vehicle speed sensor is required to detect the actual vehicle speed.	hydro-motor speed sensor

Performance functions

Performance Functions		Requirements
14	**Vehicle Constant-Speed-Drive (CSD)** The CSD function will allow driving the vehicle with a constant speed, independent of the load. If the actual vehicle speed differs from the commanded speed, the CSD function will adjust the pump command to compensate the speed difference. The speed set-point can be generated either: • By an electric drive pedal or • Calculated by the pump rpm and pump command For the feedback a hydro-motor or vehicle speed sensor is required.	hydro-motor speed sensor
15	**Vehicle-Speed-Limitation** The Vehicle Speed Limitation prevents the machine from over-speeding and can be used e.g. for export machines to different countries. The vehicle speed limitation can be configured separately for each System Mode and driving direction. The feedback signal comes from: • A hydro-motor or vehicle speed sensor • The measured pump swash angle/displacement (only option AC2)	hydro-motor speed sensor or Control: B7 or C3
16	**Park-Brake-Control** The Park Brake Control digitally activates (apply/release) a park brake. Park brake activation can be by CAN signal or vehicle speed dependent with additional dependency on: • Software machine state in STOP mode • Actual pump valve current below user defined value • Actual inch pedal command exceeds user defined value. Delay times for park brake application and release are individually configurable	-
17	**Park-Brake Test-Mode** For Roller applications the Park Brake must be checked in intervals. The Park-Brake Test Mode according SAE J1472 / EN500-4 allows the hydrostatic transmission system to drive against the applied park brake and can be individually configured for each System Mode.	-
18	**Dynamic Brake Light Control** The dynamic Brake Light control uses the inch signal to trigger a digital output for the brake light.	-
19	**Forward- and Reverse-Direction Output** The Forward and Reverse Direction Output function digitally drives lamps or LED's to indicate the selected driving direction from the FNR.	-
20	**Reverse-Driving-Direction-Buzzer-Output** The Reverse Driving Direction Buzzer Output controls a buzzer that indicates reverse driving direction. The output logic can be directly controlled by FNR status or by actual propel movement	-

Functions

Performance Functions		Requirements
21	**Vehicle-Speed-Dependent Output-Signal** The Vehicle Speed Dependent Output Signal toggles a digital output when the actual vehicle speed exceeds a user defined speed. It can be used e.g. for a speed dependent load stabilizer valve.	-
22	**Retarder Control** The engine Speed Dependent Retarder Control toggles a digital output when the actual engine rpm exceeds a user defined level. The Retarder can activate a valve of the work hydraulic to give load to engine and prevent an over speeding.	-
23	**Status-Output (Red-LED)** In case of an Error, the status LED shows a blink code. The LED is continuously on, if the Start Protection is activated.	-
24	**Pump Hysteresis Compensation** The pump hysteresis incurred while stroking or de-stroking the swash plate is measured in the factory. The hysteresis value is stored in the controller and will used to correct pump command.	-
25	**Temperature Compensation** An integrated sensor will measure the temperature to compensate the oil viscosity influence. Parameter for high and cold temperature will adjust the pump command.	-
26	**J1939-CAN Subsystem-Data Interface** The AC Control can exchange information with the vehicle system via the CAN bus. The following standard messages are supported: TSC1 (Torque/speed control), EEC1 (pump/ engine rpm), EEC2 (drive pedal), EBC1 (Inch pedal), ETC5 (FNR), VH (vehicle hours), RCI (brake remote control), OPS (operator presence), CCVS (vehicle speed), VEP1 (battery voltage), TRF1 (oil temperature). Additional Danfoss Power Solutions specific (proprietary) messages are available to share information about Mode switches, Hydro motor rpm, Transmission state and error messages. All messages can be individually activated and designated for usage.	-
27	**J1939-CAN Pedal Calibration** The calibration of the inch and drive pedal may be started via an external CAN interface (e.g. dash board).	-
28	**ECO Fuel Saving Mode** The ECO Mode will reduce the diesel engine rpm to save fuel during transport. The function can be enabled in each of the four driving modes. The activation of the ECO Mode will be automatically when the vehicle speed reaches the defined ECO speed.	Control A7 or C2 Special Setting D3E or D4E
29	**Cruise Control** The Cruise Control function is designed for a work mode with fixed engine speed. The driver can "store" the vehicle speed and release the driver pedag. The Cruice Control funtion will keep the vehicle speed constant by using different feedback signals like: vehicle speed, pump swash angle and system pressure.	Control B7 or C3 Special Setting D5J or D6J

Protection & safety functions

Protection & Safety Functions		Requirements
30	**Safety Controlled Vehicle Start-Protection** The Safety Controlled Vehicle Start Protection prevents un-commanded, unexpected, or otherwise dangerous machine propel movement after initial power on of the AC system. The Start Protection is monitoring the following signals: • Engine Rpm • Battery Voltage • Error Status • Inch Calibration • FNR in Neutral If all conditions are fulfilled the Start Protection will switched OFF and the vehicle can drive.	-

Functions

Protection & Safety Functions		Requirements
31	**Operator-Presence-Detection** The Operation Presence Detection monitors the presence of the operator in the seat (seat switch) and optional the current activity (Throttle, Drive Pedal, Inch Pedal). It will stop the machine under predefined circumstances.	-
32	**Hydraulic-System Overheat Protection and Low-Temperature Protection** An integrated sensor will measure the temperature. The function protects the complete hydrostatic system by reducing the pump flow (by pump command) at extreme high or low temperatures according to user defined temperature curve.	-
33	**Hydro-Motor Over Speed Protection** The Hydro-Motor Over Speed Protection prevents the hydrostatic motor from over speeding by either decreasing pump displacement or increasing motor displacement. The hydro-motor rpm speed limit, is user defined and valid in all four System Modes when activated.	-
34	**SIL2 Certification/Compliance** The H1-AC fulfills the requirements of the guidelines accordant to IEC 61508, SIL2 (Functional safety of electrical / electronic / programmable electronic safety-related systems (1998-2000)). The specified documents have been presented to the certification body TÜV NORD, Hamburg. The electronic hardware and the hardware development process comply with the requirements of IEC 61508-1 (version 1998-12), subset for hardware, and IEC 61508-2 (version 2000-05), SIL2. The software and the system development process comply with the requirements of IEC 61508-1 (version 1998-12), subset for software and system, and IEC 61508-3 (version 2000-05), SIL2. The SIL2 compliance will support and accelerate the certification process on vehicle system level at the customer. The H1-AC can be used in safety-related systems with a max. Performance Level (PL) d (ISO13849-1) or SILCL2 (IEC62061). All wires, sensors or actuators that are connected to the H1-AC have to verified and validated against the safety requirements on machine level by the customer.	Special Setting D3H, D4H, D5H or D6H

Engine control & protection

Engine Control & Protection		Requirements
35	**J1939-CAN Engine Interface** The AC Control can exchange information with the engine via the CAN J1939 protocol. All CAN messages can be individually activated and designated for usage. The following functions and standard messages are provided: • Engine speed control (TSC1) via redundant drive pedal • Engine Anti-Stall protection • Engine Overspeed protection during inching • Engine Overspeed protection with Retarder function • Cold start protection	-
36	**Engine Speed Control** An electric drive pedal with redundant input can be connected to the AC Control. The Engine Speed setpoint is transmitted via CAN TSC1 to the engine controller.	-
37	**Engine Anti-Stall Protection** The Engine Anti-Stall prevents the engine from being stalled due to overload through the transmission system. If the engine is drooped, the engine anti-stall function will reduce the pump command to reduce the engine load and prevent the engine from stalling.	-
38	**Engine Over Speed Protection During Inching** To decelerate the vehicle, the inch command will decrease the pump command. The pump displacement is reduced and the engine rpm will rise due to high oil flow. The engine overspeed protection will reduce the inch command proportional if the engine rpm is above the configured level. When the pump displacement increases, the engine rpm will be reduced.	-

Functions

Engine Control & Protection		Requirements
39	**Engine Over Speed Protection with Retarder** The engine rpm dependent Retarder Control toggles a digital output when the actual engine rpm exceeds a user defined level. The Retarder can activate a valve of the work hydraulic to give load to engine and prevent an over speeding.	Special Setting D3E, D4E, D5J or D6J
40	**Cold Start Protection** An integrated sensor will measure the system temperature. When the temperature is lower than a user defined level, the engine rpm command (TSC1) is limited till the system is warmed up to protect the engine and the hydraulic system..	-
41	**J1939-CAN Engine rpm Monitoring** The AC control commands the CAN Engine via (TSC1) message and monitors the engine/ pump rpm by the integrated rpm sensor. The engine rpm command can be modified by an external controller, but only if the vehicle is in Stop mode. If the engine rpm command is modified by an external controller while driving, the AC control handle it as an error and ramp down into Safe mode to stop the vehicle.	-

SIL 2 requirements

The H1-AC fulfills the requirements of the guidelines accordant to IEC 61508, SIL2 (Functional safety of electrical / electronic / programmable electronic safety-related systems (1998-2000)). The specified documents have been presented to the certification body TÜV NORD, Hamburg.

The electronic hardware and the hardware development process comply with the requirements of IEC 61508-1 (version 1998-12), subset for hardware, and IEC 61508-2 (version 2000-05), SIL2.

The software and the system development process comply with the requirements of IEC 61508-1 (version 1998-12), subset for software and system, and IEC 61508-3 (version 1998-12), SIL2.

The SIL2 compliance will support and accelerate the certification process on vehicle system level at the customer. The H1-AC can be used in safety-related systems with a max. Performance Level (PL) d (ISO13849-1) or SILCL2 (IEC62061). All wires, sensors or actuators that are connected to the H1-AC have to verified and validated against the safety requirements on machine level by the customer.

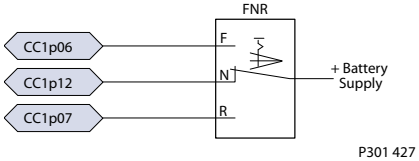
To ensure the SIL2 compliant to the IEC 61508, it is mandatory to use the certified Service-Tool Version 6.1.x for any parameter settings, changes, up- and downloads of parameter or application software.

PLUS+1® GUIDE Service Tool (IEC 61508 SIL 2 Certified)
Version: 6.1.x

CAN Input Options are not certifiable according SIL 2 of IEC 61508
Danfoss is not responsible for the function and safety third-party sensors and actuators which are connected to the AC!

General customer-sensor requirements:

FNR:



To become SIL-2 compliant, the following settings are required:

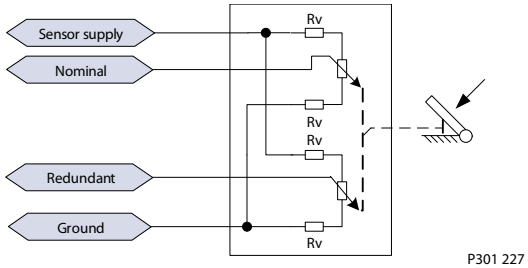
Functions

- 3-Layer switch with continuous signal
- Separate output signals for FORWARD, NEUTRAL and REVERSE indication as input signals of the AC connector pins for CC1p06, CC1p07 and CC1p12
- Switch to be supplied by Battery voltage
- Switch to be compliant to the input resistance of the digital input
- Gold-Plated contacts are recommended
- Input Selector Configuration:
  - **FNR-Source:** FNR Signal from digital inputs [Parameter 807]
  - **FNR-Signal Interpretation:** F or R or N held (continuous signal) [Parameter 897]

If no SIL-2 compliance is required, the following settings are possible:

- 2-Layer switch for FORWARD and REVERSE minimum
- **FNR-Source:** FNR Signal from digital inputs on via CAN Bus
- **FNR-Signal Interpretation:** held or momentary

Drive/Creep/Joystick/Rocker & inch pedal:



To become SIL-2 compliant, the following settings are required:

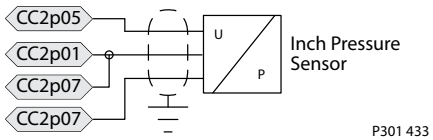
- Sensor must be supplied with AC sensor supply voltage and must not exceed the max output current (overload).
- This sensor must produce two electrically independent output signals that are in direct correlation with each other. The difference of the two input signals should be 500 mV. The redundant tolerance should set to +/- 200mV.
- The first output signal is used as the source of pedal position signal. It must rise when the pedal is pressed. The second output signal is used for diagnostic purposes.
- In case of an internal detected error, the sensor output signal has to be clamped by the sensor itself to sensor supply voltage. This feature enables the software application to recognize this failure.
- The voltage range of the output signals must not be lower than 5% and not higher than 95% of sensor voltage. Upper and lower voltage limits to sensor supply are requested for wire-fault detection.

If no SIL2 compliance is required, the following settings are possible:

- A single output (not redundant) is possible.

The Joystick or Rocker Pedal function is not SIL2 compliant.

Pressure inch sensor:



To become SIL-2 compliant, the following settings are required:

Functions

- Sensor must be supplied with AC sensor supply voltage and must not exceed the max output current (overload)
- The signal must rise when the pedal is pressed.
- The voltage range of the output signals must not be lower than 5% and not higher than 95% of sensor voltage. Upper and lower voltage limits to sensor supply are requested for wire-fault detection
- In case of an internal detected error, the sensor output signal has to be clamped by the sensor to sensor supply voltage. This feature enables the software application to recognize this failure.

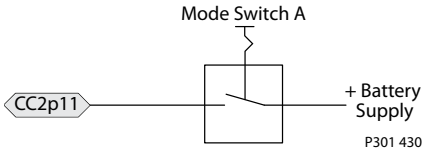
When using an inch pedal without mechanic brake function:

- This sensor must produce two electrically independent output signals that are in direct correlation with each other. The difference of the two input signals should be 500 mV. The redundant tolerance should set to +/- 200mV.

When using a hydraulic brake function with brake pressure sensor:

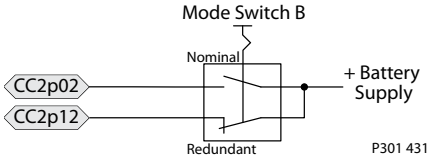
- A redundant signal is not needed. A Single output signal is sufficient, because the redundancy is here given by the hydraulic brake system and the direct measurement of the braking pressure. The inch function is only supporting the vehicle brake system to prevent driving against the brakes.
- Recommended pressure sensors MBS 1250 **#11062087**

Mode switch A:



- Switch to be supplied by Battery voltage
- Switch to comply with input resistance of the digital input
- No loads (e.g. valve) in parallel
- Gold-Plated contacts are recommended

Mode switch B:

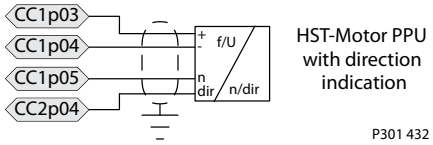


- Switching logic to be diverse redundant (opening and closing in parallel)
- Switch to be supplied by Battery voltage
- Switch to comply with input resistance of the digital input
- No loads (e.g. valve) in parallel
- Gold-Plated contacts are recommended
- Input Selector Configuration (Software Parameter settings):
  - For all system mode changes from Automotive and Creep-Automotive to Non-Automotive and vice versa, the parameter **"Mode Switch B Redundant"** must be configured to value [1] = "Redundant"

    For Automotive to Creep-Automotive and vice versa this is not mandatory.

Functions

HST-motor-PPU with optional direction indication:



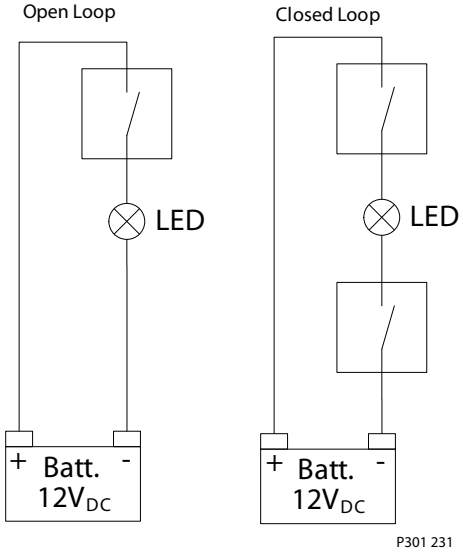
- Sensor must be supplied by the sensor supply voltage of the H1-AC and should not overload the output
- Upper and lower voltage limits for the output signals below sensor supply are required for wire-fault detection
- The voltage range of the output signals must not be lower than 6% and not higher than 94% of sensor voltage
- PPU must comply with input resistance of the RPM and analog input
- Recommended speed and direction sensor: **#11046759**

Motor displacement and Brake Pressure Defeat (BPD)

- The digital and PWM Outputs are supplied with battery voltage and must not exceed the max output current (overload)

General customer-actuator requirements:

- In General there are two different circuit designs available:

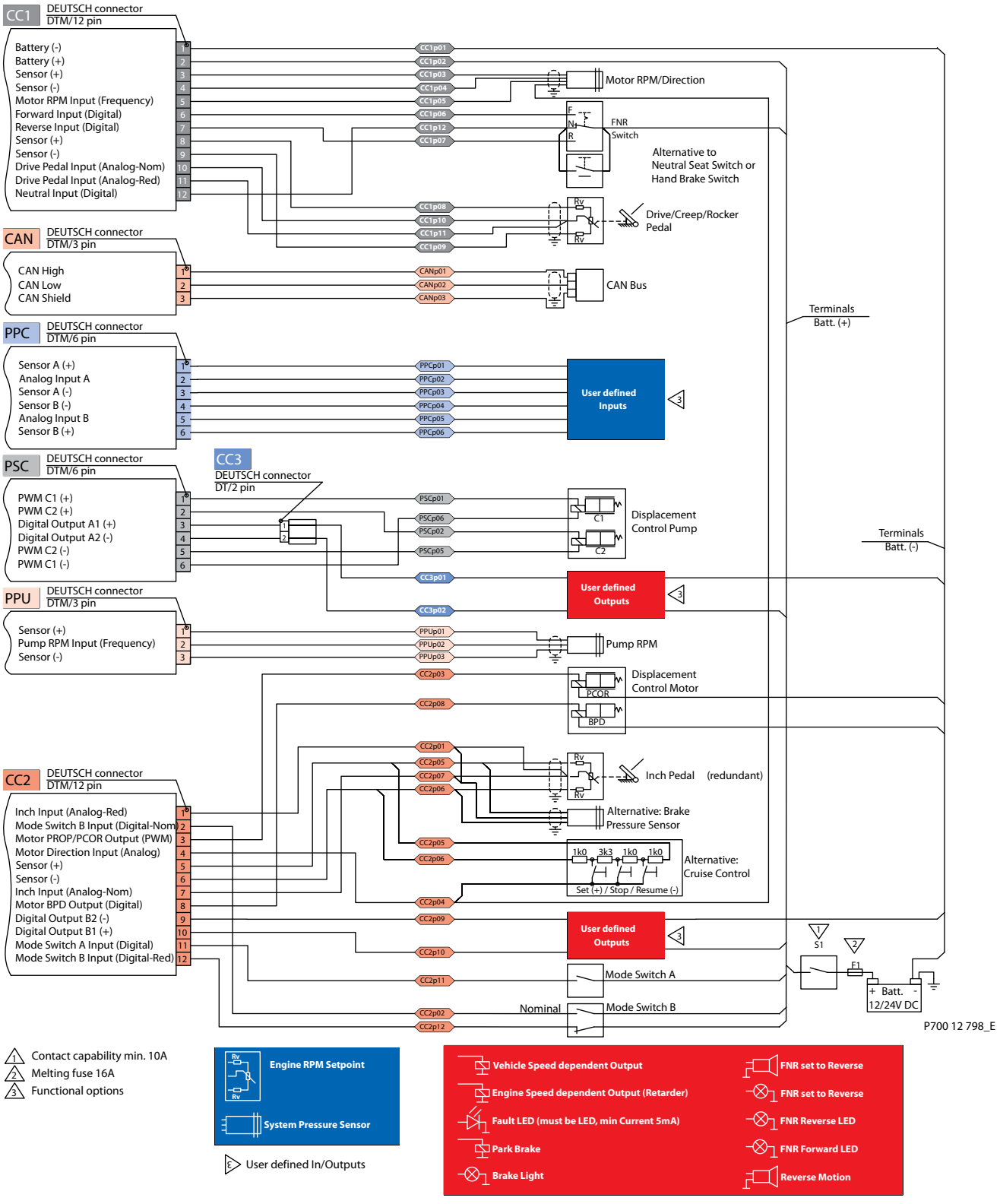


Digital outputs A1/A2 and B1/B2

- Safety relevant functions (like Brake Light Control, Park Brake Control, Reverse Motion Signal, etc.) must be connected in closed loop. The current feedback A2 (-) and B2 (-)are actively monitored, a detected fault will result in SAFE Mode operation
- The digital Outputs are supplied with battery voltage and must not exceed the max output current (overload)
- Open-loop options not compliant according SIL 2 of IEC 61508

Technical specification

Automotive Control connection diagram



Technical specification

Input signals

Power Supply [Battery (+) and Battery (-)]

The AC can be supplied with 12 V or 24 V system.

CC1: 01-Battery (-)

- Power supply input from battery (-)

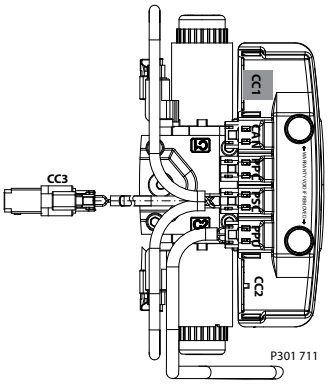
CC1: 02-Battery (+)

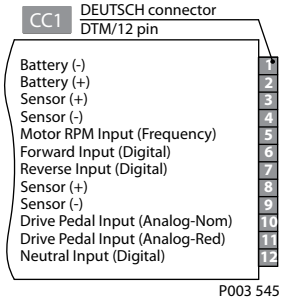
- Power supply input from battery (+)

The 5V Sensor Supply is internally generated.

The maximum supply current is 1A.

The Sensor Supply is protected against overload and reverse polarity connection.





Parameter	Min	Max	Units	Note
Battery Supply-Current	-	12	A	
Recommended fuse size	-	16	A	
Permanent Supply-Voltage-Range	9	36	V_{DC}	
Rated-12V-Range	9	16	V_{DC}	
Rated-24V-Range	18	32	V_{DC}	
Permanent Reverse-Voltage-Protection	-	-36	V_{DC}	
Sensor-Supply-Voltage-Range (internal)	4.825	5.075	V_{DC}	max 1A for all sensors together
Sensor-Supply-Current	-	1	A	
				T000 226E

Mating connectors are available from Danfoss.

For details see Mating Connectors section.

Forward-Neutral-Reverse (FNR) Switch

The FNR-switch selects the driving direction. To be SIL 2 compliant a 3-pin switch with continuous signal is required and only one digital input may be applied at a time.

The Neutral input CC1:12 can also be used for a seat switch or hand brake fucntion.

CC1:06-Forward Input

Technical specification

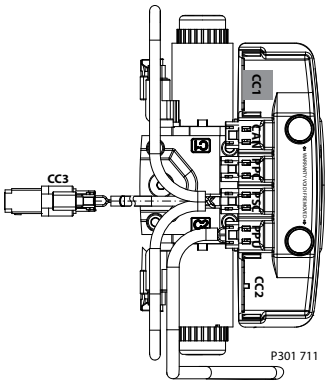
- Digital Input for driving direction FORWARD
  - Switched to battery supply (12/24 V)

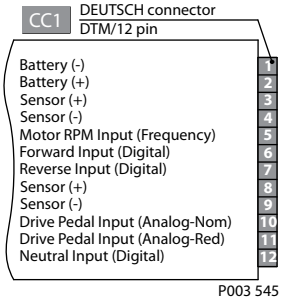
CC1:07-Reverse Input

- Digital Input for driving direction REVERSE
  - Switched to battery supply (12/24 V)

CC1:12-Neutral Input

- Digital Input for driving direction NEUTRAL
  - Switched to battery supply (12/24 V)





Parameter	Min	Max	Units	Note
Rising voltage threshold	-	7.00	Vdc	A digital input is guaranteed to be read as high if the voltage is greater than 7.00V.
Falling voltage threshold	1.66	-	Vdc	A digital input is guaranteed to be read as low if the voltage is less than 1.66V.
Input Impedance	13.4	13.8	kΩ	
				T000 224E

Mating connectors are available from Danfoss.

For details see Mating Connectors section.

Mode switch A and B

The Mode switches select the 4 possible System Modes according to the table below:

Technical specification

Modes and selection

		System mode			
		Mode 1	**Mode 2**	**Mode 3**	**Mode 4**
Mode Switch A		Low	Low	High	High
Mode Switch B	Nominal	Low	High	Low	High
	Redundant	High	Low	High	Low

To be SIL 2 compliant the Mode switch B must provide a nominal and a redundant signal.

CC2:11-Mode Switch A Input

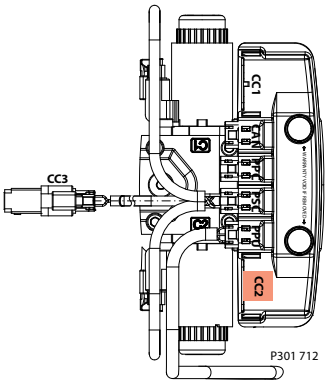
- Digital-Input for mode switch A
  - switched to battery supply (12/24V)

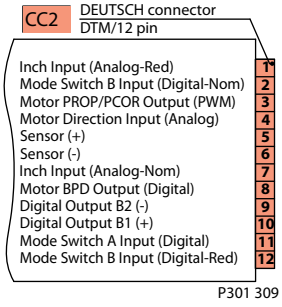
CC2:02-Mode Switch B Input (Nominal)

- Digital-Input for mode switch B (nominal)
  - switched to battery supply (12/24 V)

CC2:12-Mode switch B Input (Redundant)

- Digital-Input for for mode switch B (redundant)
  - switched to battery supply (12/24 V)





Parameter	Min	Max	Units	Note
Rising voltage threshold	-	7.00	Vdc	A digital input is guaranteed to be read as high if the voltage is greater than 7.00V.
Falling voltage threshold	1.66	-	Vdc	A digital input is guaranteed to be read as low if the voltage is less than 1.66V.
Input Impedance	13.4	13.8	kΩ	

Mating connectors are available from Danfoss.

For details see Mating Connectors section.

Inch Pedal

The inch pedal allows the operator to reduce the vehicle speed, stop the machine or keep the vehicle speed low while raising the engine speed to meet auxiliary flow demands.

Technical specification

An increasing inch pedal signal will reduce the pump displacement, thus reducing vehicle speed. Additionally, the motor can be increased to maximum displacment at the same time. The vehicle will come to a complete stop at 100 % inch signal.

CC2:01-Inch Input (Analog-Red)

- Redundant Analog Input for the Inch Signal

CC2:05-Sensor (+)

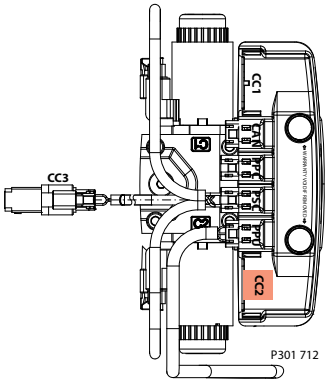
- Sensor-Supply (+)
  - Supply for sensors within 4.825 to 5.075 V
  - Max. Output-current is 200mA

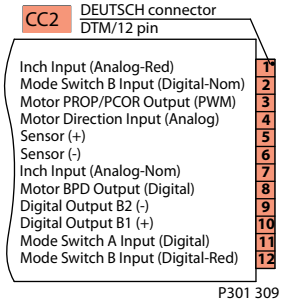
CC2:06-Sensor (-)

- Sensor-Supply (-)
  - Direct GROUND-Connection

CC2:07-Inch Input (Analog-Nominal)

- Nominal Analog Input for the Inch Signal





Parameter	Min	Max	Units	Note
Input voltage range	0.08	5.26	Vdc	
Resolution	-	12	Bit	4096 steps
Input Impedance	230	236	kΩ	
				T000 218E

Mating connectors are available from Danfoss.

For details see Mating Connectors section.

Drive/Creep Pedal, Joystick and Rocker Pedal

The Drive/Creep Pedal and the Rocker Pedal allow the operator to command the vehicle speed through pump and motor displacement setpoint. The displacement setpoint is defined by the configured profile and ramp for the 2 mode types:

Non-Automotive:

- Pump displacement controlled directly
- Motor displacement:
  - Controlled directly for 2-position and proportional control motors
  - Controlled indirectly through pressure control for PCOR control motors

Technical specification

Automotive & Creep-Automotive:

- Pump displacement only

All advanced functions, e.g. Anti stall, CSD, Over speed protection can override this command.

The Drive/Creep Pedal, Joystick only provides a driving command. The driving direction is selected by the FNR input.

The Rocker Pedal provides a driving command and the driving direction signal.

Whether a Drive/Creep Pedal, Joystick or a Rocker Pedal is used will be configered by parameters.

CAN Engine Speed Command

The drive pedal signal can be configured and sent by the AC as engine rpm command for the J1939-CAN message TSC1.

CC1:08-Sensor (+)

- Sensor-Supply (+)
- Supply for sensors within 4.825 to 5.075 V

  Max. Output-current is 200mA.

CC1:09-Sensor (-)

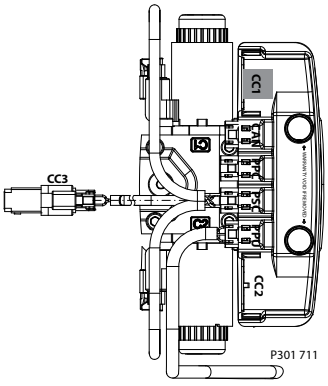
- Sensor-Supply (-)
  - Direct GROUND-Connection

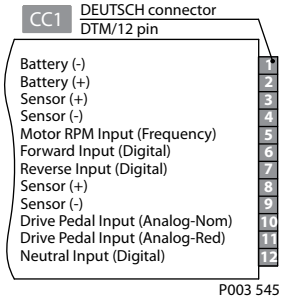
CC1:10-Drive Pedal Input (Analog-Nom)

- Nominal Analog-Input for Creep/Drive Pedal, Joystick or Rocker Pedal

CC1:11-Drive Pedal Input (Analog-Red)

- Redundant Analog-Input for Creep/Drive/Joystick or Rocker Pedal





Parameter	Min	Max	Units	Note
Input voltage range	0.08	5.26	Vdc	
Resolution	-	12	Bit	4096 steps
Input Impedance	230	236	kΩ	

T000 218E

Mating connectors are available from Danfoss.

For details see Mating Connectors section.

Technical specification

Motor Speed Sensor

A motor speed sensor signal can be read by the AC and used to calculate vehicle speed utilizing the configured final drive ratio. The calculated vehicle speed enables advanced functions such as constant speed operation and maximum vehicle speed limitation.

The optional motor direction signal can used to control the motor Brake Pressure Defeat (BPD) or the Reverse Motion signal (buzzer).

CC1:03-Sensor (+)

- Sensor-Supply (+)
- Supply for sensors within 4.825 to 5.075 V
- Max. Output-current is 200mA

CC1:04-Sensor (-)

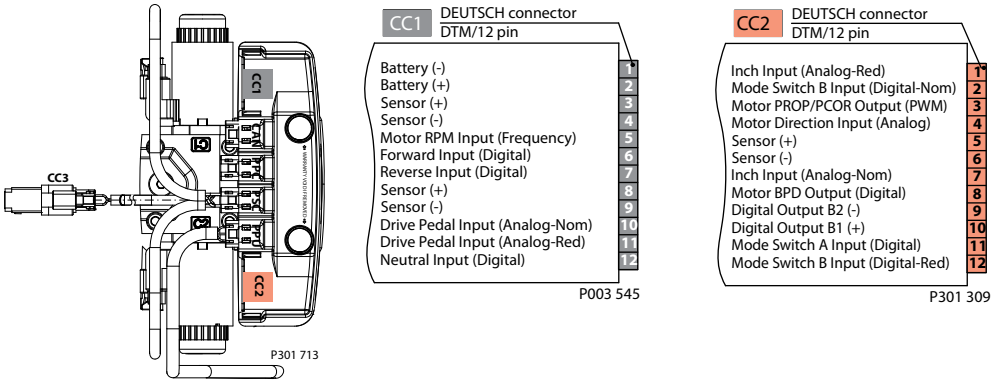
- Sensor-Supply (-)
- Direct GROUND Connection

CC1:05-Motor RPM Input (Frequency)

- Frequency-Input for HST-Motor-PPU-Sensor

CC2:04-Input (Analog)

- Analog-Input for HST-Motor-Direction
- Analog-Input for Cruise Control



Frequency Input (Motor RPM)

Parameter	Min	Max	Units	Note
Rising voltage threshold (middle range)	2	3.5	Vdc	The frequency input is guaranteed to be read as high if the voltage is greater than 3.5V
Falling voltage threshold (middle range)	0.74	-	Vdc	The frequency input is guaranteed to be read as low if the voltage is less than 0.74V
Input Impedance	7.00	7.21	kΩ	15kΩ to sensor supply / 13.5 kΩ to GND
Frequency Range	0	10 000	Hz	In steps of 1 Hz
				T000 220E

Technical specification

Analog Input (Motor Direction or Cruise Control)

Parameter	Min	Max	Units	Note
Input voltage range	0.08	5.26	Vdc	
Resolution	-	12	Bit	4096 steps
Input Impedance	-	-	kΩ	15kΩ to sensor supply / 14.1 kΩ to GND
				T301 031E

The Motor Direction function not availabe with special settings D5J and D6J - Cruise Control

Depending on the Application Software Version (Special Settings) this input is used for one of the following functions:

- Motor Direction function
- Cruise Control

Mating connectors are available from Danfoss.

For details see Mating Connectors section.

Analog Inputs

Two analog inputs can be read by the AC. The function differs, depending of the used application software version.

PPC:01-Sensor A (+)

- Sensor-Supply (+)
- Supply for sensors within 4.825 to 5.075 V
- Max. output-current is 200mA

PPC:02-Analog Input A

- Analog Input

PPC:03-Sensor A (-)

- Sensor-Supply (-)
- Direct GROUND Connection

PPC:04-Sensor B (-)

- Sensor-Supply (-)
- Direct GROUND Connection

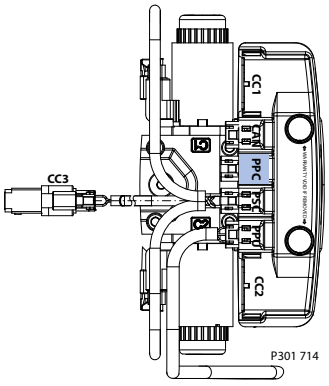
PPC:05-Analog Input B

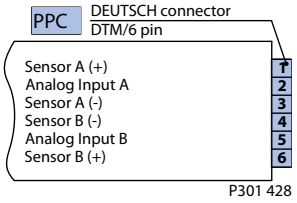
- Analog Input

PPC:06-Sensor B (+)

- Sensor-Supply (+)
- Supply for sensors within 4.825 to 5.075 V
- Max. output-current is 200mA

Technical specification





Analog Input

Parameter	Min	Max	Units	Note
Input voltage range	0.08	5.26	Vdc	
Resolution	-	12	Bit	4096 steps
Input Impedance	230	236	kΩ	
				T301 099E

Mating connectors are available from Danfoss.

For details see Mating Connectors section.

Output signals

Motor Displacement and Brake Pressure Defeat (BPD) Control

Variable displacement and 2-Position motors can be controlled direcly.

The output signal may be controlled by pump (engine) speed or drive pedal position.

For vehicle braking conditions a Brake Pressure Defeat (BPD) valve can be controlled dependent on the driving direction.

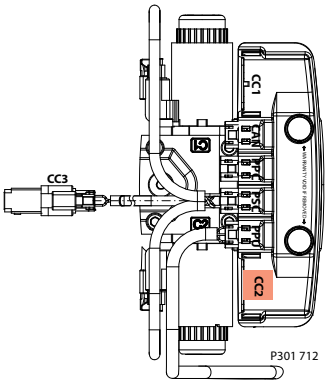
CC2:03-Motor PROP/PCOR Driver

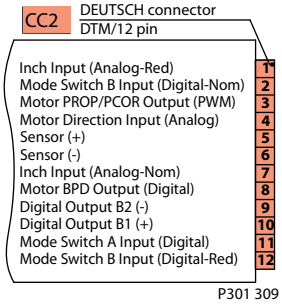
- Proportional-Output (+) for the Pressure-Control-Override or Proportional-Motor Valve
  - PWM Signal from battery Supply (12/24V)

CCC2:08-Motor BPD Driver

- Digital-Output for the Brake-Pressure-Defeat (BPD) Valve
  - Switched to battery (+) supply (12/24V)

Technical specification





PWM Output for Motor Displacement Control

Parameter	Min	Max	Units	Note
Proportional Current	0	3.0	A	
Output voltage	-	Supply		Output voltage is supply voltage!
PWM frequency	33	200	Hz	
				T000 223E

Digital outputs

Parameter	Min	Max	Units	Note
Output Current	0	3.0	A	
				T000 224E

Mating connectors are available from Danfoss.

For details see Mating Connectors section.

Digital Output A1 and A2

The digital outputs A1 and A2 can be used as single outputs (open loop - switch to battery supply or GND) or in closed loop. Only the closed loop variant is compliant according SIL 2.

The outputs can be configured individually to operate as:

- Brake Light Control
- Vehicle Speed Dependent signal
- Status Signal (Error LED)
- Reverse Motion Signal
- Engine speed dependent Retarder Control
- FNR in Reverse Signal
- Cruise Control on

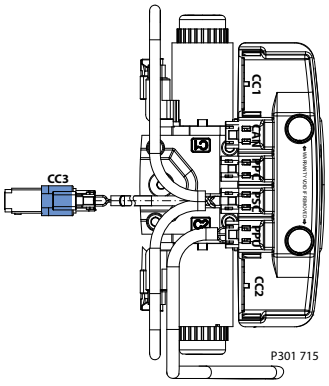
CC3:01-A1 (+)

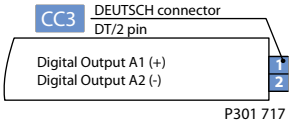
- Digital-Output
  - Switched to battery (+) supply

CC3:02-A2 (-)

- Digital-Output
  - Switched to GND (-)

Technical specification





Parameter	Min	Max	Units	Note
Output Current	0	3.0	A	
Output voltage A1(+) / B1(+)	-	Supply		Output voltage is supply voltage!
Output voltage A2(-) / B2(-)	-	GND		Output voltage Ground (GND)
				T301 030E

Mating connectors are available from Danfoss.

For details see Mating Connectors section.

Digital Output B1 and B2

The digital outputs B1 and B2 can be used as single outputs (open loop - switch to battery supply or GND) or in closed loop. Only the closed loop variant is compliant according SIL 2.

The outputs can be configured individually to operate as:

- Reverse Motion Signal
- FNR in Reverse Signal
- Park Brake Control
- Brake Light control
- Status Signal (Error LED)
- FNR in Forward Signal
- Engine speed dependent Retarder Control

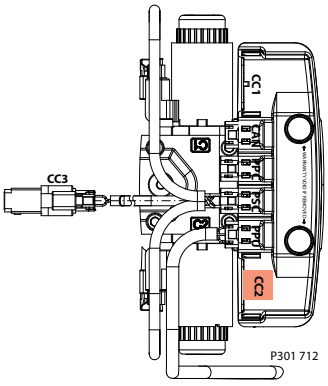
CC2:09-Digital Output B2 (-)

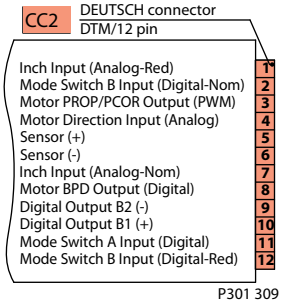
- Digital Output
  - Switched to GND (-)

CC2:10-Digital Output B1 (+)

- Digital-Output
  - Switched to battery (+) supply

Technical specification





Parameter	Min	Max	Units	Note
Output Current	0	3.0	A	
Output voltage A1(+) / B1(+)	-	Supply		Output voltage is supply voltage!
Output voltage A2(-) / B2(-)	-	GND		Output voltage Ground (GND)
				T301 030E

Mating connectors are available from Danfoss.

For details see Mating Connectors section.

CAN communication

CAN communication

The AC Control can exchange information with the vehicle system via CAN bus.
The physical (hardware) layer operates using the CAN 2.0B specification according ISO 11898-2. The CAN interface is used for application software downloads and parameter settings.

CAN:01-CAN High

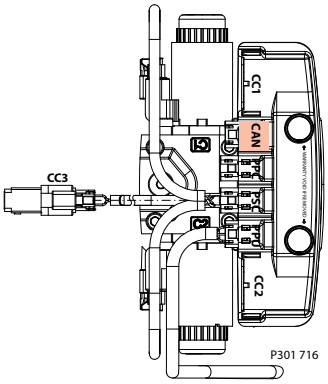
- Communication-Connection for CAN-High-Line

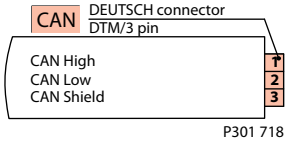
CAN:02-CAN Low

- Communication-Connection for CAN-Low-Line

CAN:03-CAN Shield

- Communication-Connection for CAN-Shield





Technical specification

CAN Communication

Parameter	Min	Nom	Max	Units	Note
CAN Baudrate			250	kBaud	Physical Layer as per ISO11898-2 High speed
					T000 237E

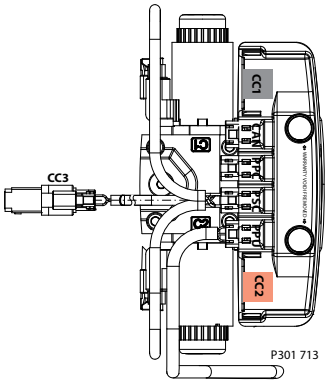
Mating connectors are available from Danfoss.

For details see Mating Connectors section.

Mating Connectors

Customer Connector 1 (CC1) and 2 (CC2)

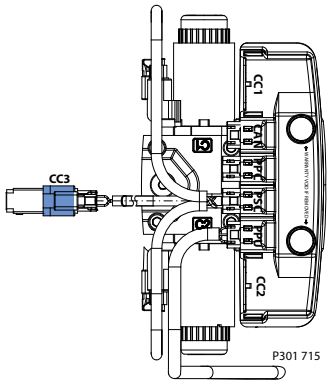
There are 2 available kits, differentiated by customer wire diameter, containing both CC1 and CC2 mating connectors.



Connector	Lead wire diameter	Material number	Name	Information
Customer Connector 1 (CC1) and 2 (CC2)	0.5-1.0 mm² / (16-20 AWG)	10102023	Assembly Bag with 2 DEUTSCH Connectors DTM06 12-SOCKET Black/Grey and gold plated pins	
	0.2-0.5 mm² / (20-24 AWG)	10100945	Assembly Bag with 2 DEUTSCH Connectors DTM06 12-SOCKET Black/Grey and gold plated pins	recommended
				T000 227E

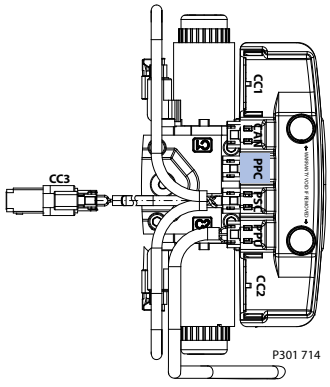
Technical specification

Customer Connector 3 (CC3)



Connector	Lead wire diameter	Material number	Name	Information
Customer Connector 3 (CC3)	0.5-2.0 mm² / (14-20 AWG)	11070531	Assembly Bag with 1 DEUTSCH Connectors DT04 2-SOCKET Grey and gold plated pins	
				T301 032E

Connector PPC

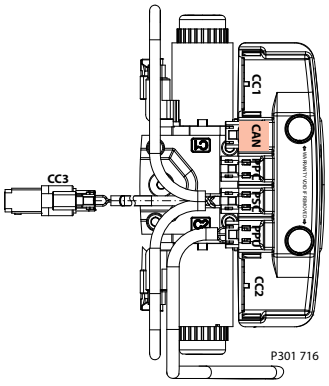


Connector	Lead wire diameter	Material number	Name	Information
PPC	(20-24 AWG) / 0.2 – 0.5 mm²	11033865	Assembly Bag with one DEUTSCH Connector DTM06 6-SOCKET Black	
PPC	(20-24 AWG) / 0.2 – 0.5 mm²	11033863	Assembly Bag with one DEUTSCH Connector DTM06 6-SOCKET Grey	
				T301 100E

CAN connector (CAN)

There are 2 available kits, differentiated by customer wire diameter, containing both a CAN mating connector.

Technical specification



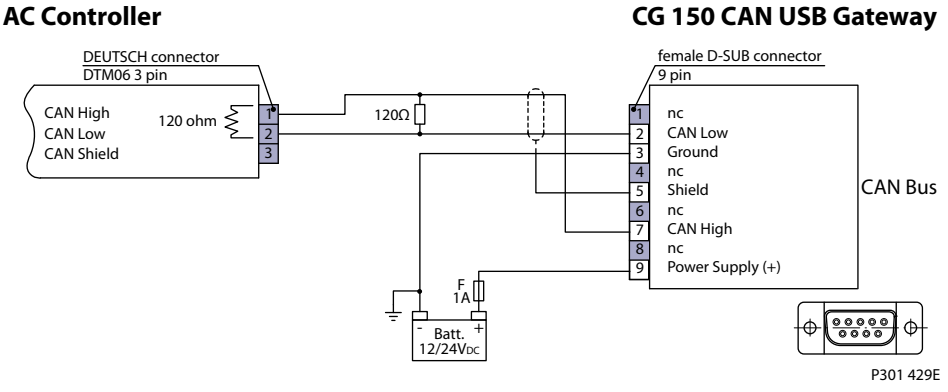
Connector	Lead wire diameter	Material number	Name	Information
CAN Connector (CAN)	0.5 – 1.0 mm² / (16-20 AWG)	11072736	Assembly Bag with 1 DEUTSCH Connectors DTM06 3-SOCKET Grey and gold plated pins	
	0.2 – 0.5 mm² / (20-24 AWG)	11033864	Assembly Bag with 1 DEUTSCH Connectors DTM06 3-SOCKET Grey and gold plated pins	recommended
				T000 228E

CAN bus adapter cable

To connect the CG150 CAN USB Gateway with the Automotive Control (AC) the below additional adapter cable is required. The pigtail cable transitions from Deutsch to DSUB connector and contains terminating resistors to enable CAN communication.

Material number	Name	Information
11069593	Adapter Cable H1P AC CAN Guide	
		T000 229E

CAN bus adapter



Technical specification

Bill of Material:

- CAN Deutsch Connector DTM06 3-SKT PLUG GY

  Material No. 11033864
- 9 pin female D-SUB Connector with housing
- 120 ohm resistor 1/4W ± 5% or better
- 1 m Cable 3 wire, diameter 0.2 to 1.0 mm² (0.5 mm² recommended)

If using a cable longer than 1 m, a shielded cable is required. For further information see the J1939 specification.

AC electrical data & characteristics

Supply characteristics

Parameter	Min	Max	Units	Note
Battery Supply-Current	-	12	A	
Recommended fuse size	-	16	A	
Permanent Supply-Voltage-Range	9	36	V_{DC}	
Rated-12V-Range	9	16	V_{DC}	
Rated-24V-Range	18	32	V_{DC}	
Permanent Reverse-Voltage-Protection	-	-36	V_{DC}	
Sensor-Supply-Voltage-Range (internal)	4.825	5.075	V_{DC}	max 1A for all sensors together
Sensor-Supply-Current	-	1	A	

I/O characteristics

Digital inputs

Parameter	Min	Max	Units	Note
Rising voltage threshold	-	7.00	Vdc	A digital input is guaranteed to be read as high if the voltage is greater than 7.00V.
Falling voltage threshold	1.66	-	Vdc	A digital input is guaranteed to be read as low if the voltage is less than 1.66V.
Input Impedance	13.4	13.8	kΩ	

Analog inputs

Parameter	Min	Max	Units	Note
Input voltage range	0.08	5.26	Vdc	
Resolution	-	12	Bit	4096 steps
Input Impedance	230	236	kΩ	

Frequency inputs

Parameter	Min	Max	Units	Note
Input voltage range	0.08	5.26	Vdc	
Resolution	-	12	Bit	4096 steps
Input Impedance	-	-	kΩ	15kΩ to sensor supply / 14.1 kΩ to GND

Technical specification

Analog input (motor direction)

Parameter	Min	Max	Units	Note
Rising voltage threshold (middle range)	2	3.5	Vdc	The frequency input is guaranteed to be read as high if the voltage is greater than 3.5V
Falling voltage threshold (middle range)	0.74	-	Vdc	The frequency input is guaranteed to be read as low if the voltage is less than 0.74V
Input Impedance	7.00	7.21	kΩ	15kΩ to sensor supply / 13.5 kΩ to GND
Frequency Range	0	10 000	Hz	In steps of 1 Hz

Digital/PWM-outputs and current feedbacks

Parameter	Min	Max	Units	Note
Proportional Current	0	3.0	A	
Output voltage	-	Supply		Output voltage is supply voltage!
PWM frequency	33	200	Hz	

Ditigal output

Parameter	Min	Max	Units	Note
Output Current	0	3.0	A	

Operating characteristics

Temperature range

Parameter	Min	Max	Units	Note
Application software download	0	70	°C	
Parameter download	-40	104	°C	

See also Temperature range in Fluid Specification section.

CAN communication

Parameter	Min	Nom	Max	Units	Note
CAN Baudrate			250	kBaud	Physical Layer as per ISO11898-2 High speed

Speed sensor

Speed ring number of teeth	Number
H1P 045/053 Single	79
H1P 060/068 Single	86
H1P 069/078 Single	86
H1P 089/100 Single	92
H1P 115/130 Single	102
H1P 147/165 Single	108

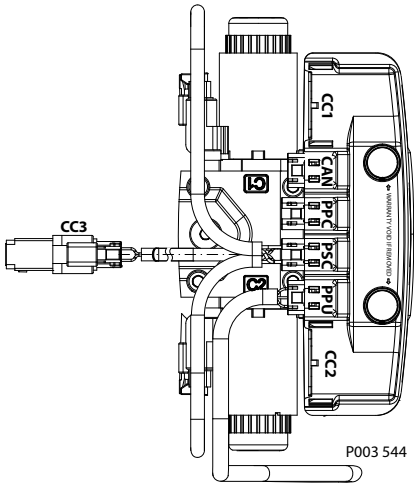
Technical specification

Environmental and protection characteristics

Parameter	Note
Short circuit	All inputs and outputs will withstand continuous short circuit to all other leads. When the short circuit is removed the unit returns to normal function.
EMC-Immunity (EMI)	According to EN 61000-6-2 EMC generic standard for immunity, industrial environment - incl. 1kHz w/ AM 80%
EMC-Emission (RFI)	EN 61000-6-3 EMC generic standard for emission, residential and industrial enviroments. EN 12895 for industrial trucks.
ESD	EN 61 000-4-2 Electrostatic discharge immunity test Level 4. Direct contact discharge to connector pins.
Automotive transients	ISO 7637 / 1-3
Temp/Volt/Humidity	IEC 60068-2-38
Cold test	IEC 60068-2-1 AD
Dry heat	IEC 60068-2-2 BD
Ice water shock	ISO 16750-4
Salt mist	IEC 60068-2-11 test Ka
IP67 & IPX9K*	IEC 60529 & DIN 40050 part 9 (valid for control only!)
* with installed plug	

Automotive Control (AC) options AC-1: A7(12 V)/C2 (24 V) and AC-2: B7(12 V)/C3 (24 V)

The AC-1 and AC-2 propel transmission system consists of an H1 variable pump, embedded electronic controller, and service tool configurable PLUS+1 software that allows the customer to completely optimize vehicle performance. The embedded electronic controller provides an electric input signal activating one of two solenoids that port charge pressure to either side of the pump servo cylinder. The AC has no mechanical feedback mechanism but AC-2 is available with an electronic feedback signal for the swash plate position.



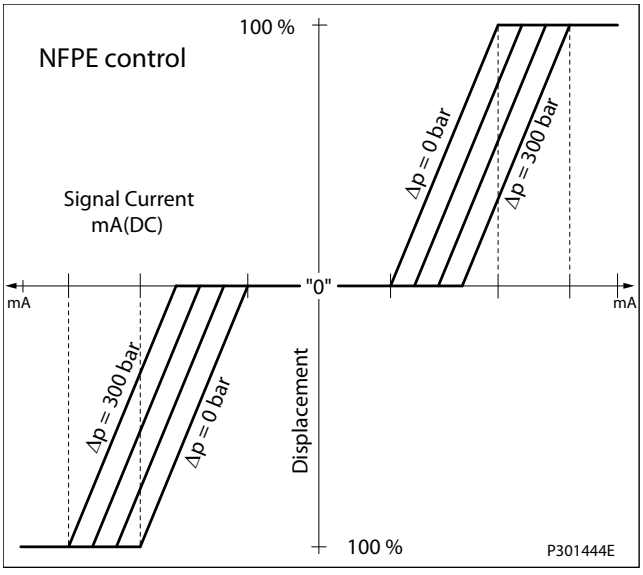
The pump displacement is proportional to the solenoid signal current, but it also depends upon pump input speed and system pressure. This characteristic also provides a power limiting function by reducing the pump swash plate angle as system pressure increases. A typical response characteristic is shown in the accompanying graph.

Technical specification

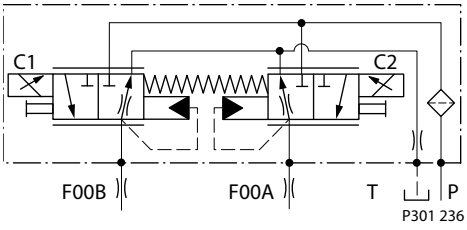
Under some circumstances, such as contamination, the control spool could stick and cause the pump to stay at some displacement.

A serviceable 125 µm screen is located in the supply line immediately before the control porting spool.

Pump displacement vs. input pignal



Automotive Control (AC) schematic



Solenoid data

Voltage	**12V**	**24V**
Maximum current	1800 mA	920 mA
Coil resistance @ 20 °C [70 °F]	3.66 Ω	14.20 Ω
Coil resistance @ 80 °C [176 °F]	4.52 Ω	17.52 Ω
PWM Range	70-200 Hz	
PWM Frequency (preferred)*	100 Hz	
Inductance	33 mH	140 mH
IP Rating (IEC 60 529) + DIN 40 050, part 9	IP 67	
IP Rating (IEC 60 529) + DIN 40 050, part 9 with mating connector	IP 69K	
* PWM signal required for optimum control performance.		

Technical specification

Pump output flow direction vs. control signal

Shaft rotation	CW		CCW	
Coil energized*	**C1**	**C2**	**C1**	**C2**
Port A	in	out	out	in
Port B	out	in	in	out
Servo port pressurized	M5	M4	M5	M4
* For coil location see installation drawings.				

H1 controls are available with optional control passage orifices to assist in matching the rate of swashplate response to the application requirements (e.g. in the event of electrical failure). Software ramp or rate limiting should be used to control vehicle response in normal operation. The time required for the pump output flow to change from zero to full flow (acceleration) or full flow to zero (deceleration) is a net function of spool porting, orifices, and charge pressure. A swashplate response table is available for each frame indicating available swashplate response times. Testing should be conducted to verify the proper software and orifice selection for the desired response.

H1 pumps are limited in mechanical orificing combinations. Software is envisioned as the means to control the swashplate response in normal operating conditions. Mechanical servo orifices are to be used only for fail-safe return to neutral in the event of an electrical failure.

Typical response times shown below at the following conditions:

Δp = 250 bar [3626 psi]

Viscosity and temperature = 30 mm^2/s (50 °C) [141 SUS (122 °F)]

Charge pressure = 20 bar [290 psi]
Speed = 1800 min^{-1} (rpm)

Response times

Displacement	Stroking direction	0.8 mm [0.03 in] orifice	1.3 mm [0.05 in] orifice	No orifice
045/053 cm^3	Neutral to full flow	2.2	1.1	0.7
	Full flow to Neutral	1.3	0.7	0.3
060/068 cm^3	Neutral to full flow	3.3	1.6	1.0
	Full flow to Neutral	2.6	0.8	0.4
069/078 cm^3	Neutral to full flow	3.1	1.4	0.8
	Full flow to Neutral	2.0	0.9	0.4
089/100 cm^3	Neutral to full flow	4.3	1.9	1.1
	Full flow to Neutral	2.6	1.1	0.5
115/130 cm^3	Neutral to full flow	5.1	2.5	1.5
	Full flow to Neutral	3.2	1.4	0.7
147/165 cm^3	Neutral to full flow	5.8	2.1	1.3
	Full flow to Neutral	2.4	1.6	1.2

Manual Over Ride (MOR)

All Automotive AC-1 and AC-2 controls feature a Manual Over Ride (MOR) for temporary actuation of the control to aid in diagnostics.

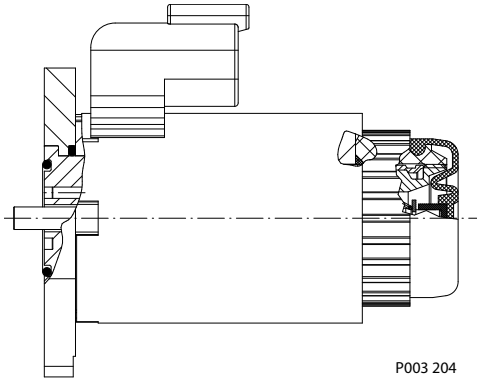
Technical specification

Unintended MOR operation will cause the pump to go into stroke. The vehicle or device must always be in a “safe“ condition (i.e. vehicle lifted off the ground) when using the MOR function. The MOR plunger has a 4 mm diameter and must be manually depressed to be engaged. Depressing the plunger mechanically moves the control spool which allows the pump to go on stroke. The MOR should be engaged anticipating a full stroke response from the pump.

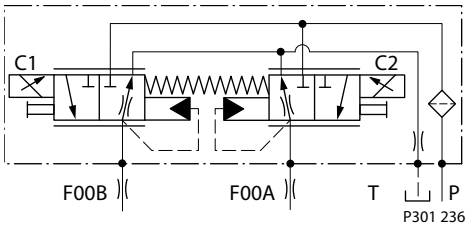
Warning

Initial actuation of the o-ring seal MOR plunger will require a force of 45 N. Additional actuations typically require less force to engage the MOR plunger. Proportional control of the pump via the MOR is not intended.

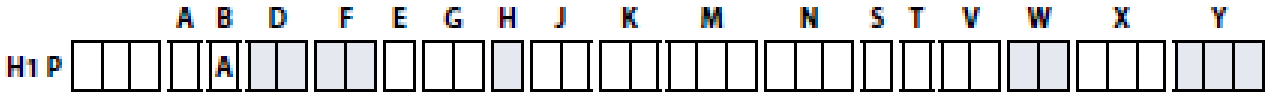
Refer to control flow table for the relationship of solenoid to direction of flow.



MOR-Schematic diagram (AC shown)



Model code



Displacement

045/053/060/068/069/078/089/100/115/130
45.0 cm³ [2.75 in³] / **53.8 cm³** [3.28 in³] / **60.4 cm³** [3.69 in³] / **68.0 cm³** [4.15 in³] / **69.2 cm³** [4.22 in³] / **78.1 cm³** [4.77 in³] / **89.2 cm³** [5.44 in³] / **101.7 cm³** [6.21 in³] / **115.2 cm³** [7.03 in³] / **130.0 cm³** [7.93 in³] / **147.2 cm³** [8.98 in³] / **165.1 cm³** [10.08 in³]

***D** Control*

A7	AC-1, Automotive Control 12 V, Manual override *(align with option E: Displacement Limiters & option, W: Special Hardware, Y: Special settings)*
C2	AC-1, Automotive Control 24 V, Manual override *(align with option E: Displacement Limiters & option, W: Special Hardware, Y: Special settings)*
B7	AC-2, Automotive Control 12 V, with Swash Plate Angle Sensor and Manual override *(align with option E: Displacement Limiters & option, W: Special Hardware, Y: Special settings)*
C3	AC-2, Automotive Control 24 V, with Swash Plate Angle Sensor and Manual override *(align with option E: Displacement Limiters & option, W: Special Hardware, Y: Special settings)*

***F** Orifices*

C1	Orifices, 0.8 mm in servo supply 1 and 2, recommended for propel applications
C2	Orifices, 1.3 mm in servo supply 1 and 2 (Standard), recommended for propel applications
C3	No orifice, recommended for non-propel applications

***H** Mounting Flange (Speed Sensor)*

J	45-53 cm³ SAE B 2 Bolt and speed sensor
K	60-100 cm³ SAE C 4 Bolt and speed sensor
L	115-130 cm³ SAE D 4 Bolt and speed sensor
G	147-165 cm³ SAE D 4 Bolt and speed sensor

***W** Special Hardware Features*

P2	AC valve plate with speed sensor *(align with option D: Control selection and option E: Displacement limiters)*

***Y** Special Settings (Align with Option D: Control Selection)*

D3E	AC-1, control, System E: Functional basis, CAN J1939 in/out, ECO Fuel Saving Mode, without Customer Files	control option A7 12V
D3F	AC-1, control, System F: Functional basis, CAN J1939 in/out without Customer Files	
D3H	AC-1, control, System H: Functional basis, CAN J1939 out, SIL2 compliant without Customer Files	
D4E	AC-1, control, System E: Functional basis, CAN J1939 in/out, ECO Fuel Saving Mode, without Customer Files	control option C2 24V
D4F	AC-1, control, System F: Functional basis, CAN J1939 in/out without Customer Files	
D4H	AC-1, control, System H: Functional basis, CAN J1939 out, SIL2 compliant without Customer Files	
D5F	AC-2 control with Swash Plate Angle Sensor, System F: Functional basis, CAN J1939 in/out without Customer Files	control option B7 12V
D5H	AC-2 contol with Swash Plate Angle Sensor, System H: Functional basis, CAN J1939 out, SIL2 compliant without Customer Files	
D5J	AC-2 contol with Swash Plate Angle Sensor, System J: Functional basis, CAN J1939 out, Cruise Control, without Customer Files	

Model code

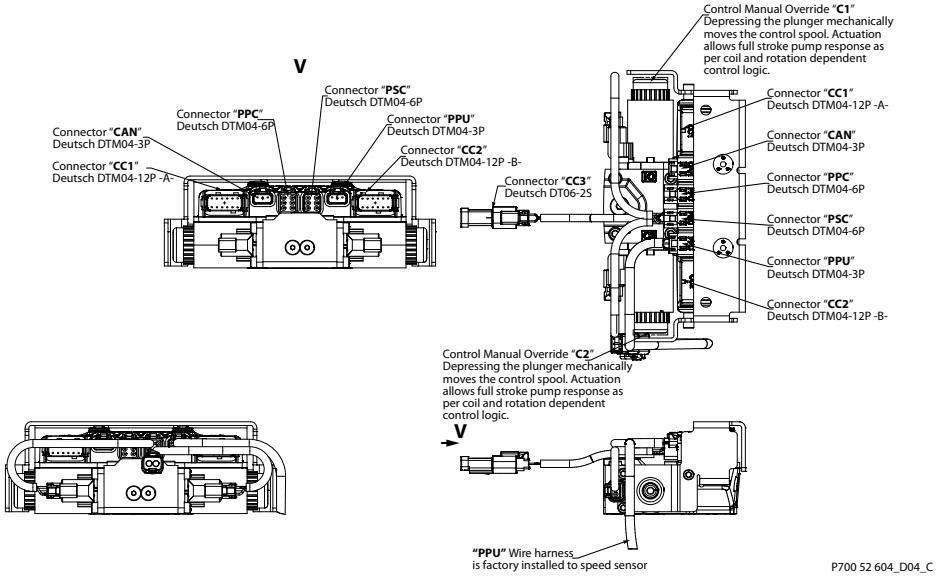
Y *Special Settings (Align with Option D: Control Selection) (continued)*

D6F	AC-2 control with Swash Plate Angle Sensor, System F: Functional basis, CAN J1939 in/out without Customer Files	control option C3 24V
D6H	AC-2 control with Swash Plate Angle Sensor, System H: Functional basis, CAN J1939 out, SIL2 compliant without Customer Files	
D6J	AC-2 control with Swash Plate Angle Sensor, System J: Functional basis, CAN J1939 out, Cruise Control, without Customer Files	

For complete model code, please refer to the Technical Information "H1 Axial Piston Pump".

Installation drawings

Dimensions



For specific installation drawings, please refer to the Technical Information (reference list - see page 2) or contact Danfoss Power Solutions.

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