Hydrostatic Drives

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Hydrostatic Transmission

→ Basic Schematic Closed Loop

- The pump (1) creates variable flow that is consumed by the motor (2) in a closed circuit arrangement
- High pressure relief valves (10) protect components
- Charge pump is protected by another relief valve (4) and supplies low pressure side via filter (5) and check valves (6)

- The loop flushing valve (7) take flow out of the low pressure side for cooling (9) and filtration
- The flush relief valve (8) ensures pressure level on low side
- High pressure sides varies based on load conditions:
  - Acceleration vs. Deceleration
  - Forward vs. Reverse
  - Uphill vs. Downhill
Define all the Vehicle and Driveline Requirements before it’s possible to size a HydroStatic Transmission, short: HST

- Vehicle Weight (un-/loaded)
- Engine Power and Speed
- Static and Dynamic Wheel Radius
- Working and Transport Speed
- Gradeability at Transport Speed
- Pull Force
- Auxiliary Pump(s)
- Final Gear Supplier and available ratios
- Limitations on Pressure
- Duty Cycle

\[
\text{HST Ratio} = \frac{P_C}{P_E}
\]

\[P_C = \text{Corner Power [kW]}\]
\[P_E = \text{Installed Engine Power [kW]}\]
Hydrostatic Transmission

→ Advantages in application

- Ground speed and tractive force independent from engine speed
  - Allows for Power Management
- High power density
- Flexibility of component arrangement
  - Transverse engine possible
  - Multiple motors possible

- Active ratio control by displacement setting of pump and motor
- Power reversals possible:
  - Engine supported braking (additional retarder might be required)
  - Reduced brake wear
  - Energy recuperation
- Smooth & stepless speed variation:
  - Acceleration & deceleration
  - Reversals & inching
  - Sensitive positioning
- **Well proven technology in various applications**
Hydrostatics

→ Product Overview

- H1 Pump
- H1 Bent Axis Motor
- Series 90 Pump
- Series 90 Motor
- Series 51 Motor
- Series 45 Pump
- Series 42 Pump
- Series 40 Pump
- Series 40 Motor
- Series 15
- DDC 20
- Series BDU
- LDU 20 Transmission
- Series K/L Motor
- Series LPV Pump
- Transit Mixer
- Accessories
- Subsystems/ Software
H1B Bent Axis Motor

→ Product Overview

- Available displacements:
  - 60, 80, 110, 160 & 250 cc (250 cc end of 2012)
- Maximum pressure 480 bar
- Stroking range 0 to 32 for max efficiency
- Design optimized for electric controls
- 0 capability (Anti-Slip, 2-Motor Transmission, ...)
- Shortest unit length on the market
- Integrated speed sensor
H1B Bent Axis Motor
Product Information

DIN-Flange

Cartridge-Flange

SAE-Flange
H1B Bent Axis Motor

Control options

Electric 2-Position (12/24V)

Electric Proportional Control (12/24V)

Hydraulic 2-Position Control

Pressure Compensator OverRide - PCOR
Electric Brake Pressure Defeat - BPD
options available with controls
PPU = Speed Sensors
H1B Performance

100 % Vi 80 °C motoring 2000 rpm

Max displacement and 2000 rpm usually is medium pressure
H1 Pump & Motor

Product Features and Benefits

- Efficiency gains can be converted to power savings, considering an overall duty cycle

- Consider pump, charge pump, and motor

- Consider a 75 Kw (100 hp) application and a composite duty cycle benefit of 10% using H1 products

<table>
<thead>
<tr>
<th>Metric (Europe)</th>
<th></th>
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<tbody>
<tr>
<td>Grey: input data</td>
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</tr>
<tr>
<td>Specific fuel consumption [g/ kWh]</td>
<td>215</td>
</tr>
<tr>
<td>Specific density of Diesel</td>
<td>0.83</td>
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<tr>
<td>Average Power savings [kW]</td>
<td>7.5</td>
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<tr>
<td>Working hours per day</td>
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</tr>
<tr>
<td>Working days per year</td>
<td>100</td>
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<tr>
<td>Price per litre Diesel [EUR]</td>
<td>€ 1.20</td>
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<tr>
<td>CO2 Production per Liter of Diesel [kg/L]</td>
<td>2.69</td>
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</table>

**Fuel savings per year [Litre]** 803

**Cost savings per year [€EUR]** €964
H1 Swash Plate Pump

→ Product Overview

- Wide Range of Displacements:
  - Medium duty: 45, 53, 60, 68 cc also Tandem 45/53
  - Heavy duty: 78, 89, 100, 115, 130, 147, 165 cc
  - Future 20, 30, 38, 210, 250 cc (210, 250 March 2013)
- Maximum pressure 450 bar
- 18° stroking angle for high power density and efficiency
- Control option aligned with machine performance
  - Electric displacement control (EDC)
  - Non Feedback Proportional Electric (NFPE)
  - Automotive Control (AC) with embedded controller for plug-and-perform hydrostatic drives
- Sensor integration possible:
  - Speed, temperature, swash plate angle & pressure
- Compact Design
# H1 Swash Plate Pump

## H1 - Technical Data

<table>
<thead>
<tr>
<th>Pump Type</th>
<th>Single</th>
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<tbody>
<tr>
<td><strong>Pump Size</strong></td>
<td>45/53</td>
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<tr>
<td><strong>Mounting Flange</strong></td>
<td>B</td>
</tr>
<tr>
<td><strong>Input speed (min⁻¹)</strong></td>
<td>Rated</td>
</tr>
<tr>
<td></td>
<td>Maximum</td>
</tr>
<tr>
<td><strong>System pressure (bar)</strong></td>
<td>Maximum Working Pressure</td>
</tr>
<tr>
<td></td>
<td>Maximum Pressure</td>
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</table>

H1P Product Presentation
<table>
<thead>
<tr>
<th>Pump Type</th>
<th>Tandem</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pump Size</td>
<td>45/53</td>
</tr>
<tr>
<td>Mounting Flange</td>
<td>B</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Input Speed (min⁻¹)</th>
<th>Tandem</th>
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</thead>
<tbody>
<tr>
<td>Rated</td>
<td>3400</td>
</tr>
<tr>
<td>Maximum</td>
<td>3500</td>
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</table>

<table>
<thead>
<tr>
<th>System Pressure (bar)</th>
<th>420</th>
<th>380</th>
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</thead>
<tbody>
<tr>
<td>Maximum Working Pressure</td>
<td>450</td>
<td>400</td>
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</table>
Electric Displacement Control (EDC)
A2 (12V)/A3 (24V)

EDC Principle

- Pump displacement proportional to input current.
- Internal mechanical swash plate position feedback.
H1 Pump Controls

EDC (Single & Tandem)

Pump Displacement vs. Control Current

EDC – Schematic Diagram

Feedback from Swash plate
H1 Pump Controls

FNR (Single & Tandem)

Forward-Neutral-Reverse (FNR) Electric Control
A9 (12V)/B1 24(V)

The 3-Position (F-N-R) control uses an electric input signal to switch the pump to a full stroke position.
H1 Pump Controls
FNR (Single & Tandem)

Pump Displacement vs. Electrical Signal

3 - Position Electrical Control, Hydraulic Schematic
H1 Pump Controls

NFPE (Single & Tandem)

Non Feedback Proportional Electric Control (NFPE)
A8 (12V)/B8 (24V)

- Pump displacement depends on System pressure and input current.
- No mechanical feedback.
H1 Pump Controls

NFPE (Single & Tandem)

Pump Displacement vs. Input Signal

NFPE Schematic
Automotive Control (AC)

AC I: A7 (12V)/C2 (24V)
AC II: B7 (12V)/C3 (24V)

- Automotive Control (AC) designed to control a single path hydrostatic transmission system consisting of one pump and one motor.

- Pump displacement controlled by configurable drive curves

- AC-1 standard, load dependant destroking

- AC-2 has additional a swashplate angle sensor to provide a second mode: load independent displacement control (EDC like behavior)
H1 Automotive Control

H1 AC Pump and H1 Bent Axis Motor

Automotive Control
• Embedded Controller as part of the pump
• Inputs for FNR, Mode switch, Inch and Drive pedal on the controller
• Outputs for motor control valves integrated
• Additional outputs for brake light, buzzer etc. available
• CAN J1939 Interface for e.g. Displays, Diesel Engine Control...
H1 Automotive Control

Functional Overview

- 4 Selectable Transmission-Modes
  - Independent Curve setting for Forward & Reverse (8 Curves)
- Electronic Inching
- Engine Overspeed & Antistall Protection
- HST-Motor Overspeed Protection
- Pump-Angle-Control*
- Constant-Speed-Control (Flow* or RPM)
- Maximum Torque at Vehicle Start
- Parking-Brake, Backup-Alarm or Brake Light Control
- Speed dependent Output Control
- Retarder Control (Engine Speed dependent Output)
- CAN-Interface
  - J1939-Engine-Interface, PLUS+1-Devices, Service & Diagnosis

* Option AC2 with Swash-Plate Sensor
**Safety Features**

- **Safety Certification for SIL-2 (IEC 61508)**
  - IEC 61508: SIL-2 ⇔ ISO 13849 PL-d
  - Complete Controller System consist of:
    - Controller Hardware
    - Application Software
    - Valves, Sensors and Cable harness

- **Hardware monitoring**
  - Detection of cable break / short circuit
  - Redundant Inputs
  - „Main Switch“ for all Valve outputs*

- **Software monitoring**
  - Plausibility check of all signal levels
  - Start Protection control (engine and battery monitoring)
  - Driver presence detection
  - Modifications and appearing faults will be stored in the controller and can be read out with the Service tool software

* In case of a failure the Valve outputs are switched off
• **Basic functionality**
  - The ECO Mode will save fuel during transport
  - The vehicle is driving with the max speed & reduced engine rpm
  - It is available in each Automotive driving mode
  - The ECO Mode will be activated automatically

• **System requirements**
  - CAN interface to diesel engine (receive setpoint TSC1)
  - Electric drive pedal connected to the Automotive Control
  - Speed sensor for the hydrostatic motor
  - Oversize (faster) hydrostatic drive than required
  - Hydrostatic motor with one of the following configurations:
    ➢ H1B with electric PCOR (Pressure Compensator Override)
    ➢ H1B with electric proportional control
Function of the Eco Drive

Eco drive control concept

- Engine Speed Max
- Motor Displacement Max
- Pump Displacement
- Vehicle Speed Max
- Motor Displacement Min

Drive Start, Max vehicle Speed in Transport Mode, ECO Mode activation, Max vehicle Speed in ECO Mode
H1 Automotive Control
Standard & Customized Pumps

Standard Material No.
- Software Package
- Default Parameter settings!
- Available to all customers.

Customer specific Material No.
- Software Package
- Customer specific Parameter settings
- Unique for Customer & Application

Check

Testing & Tuning

Customer Parameter.xml
+ AC System Document

Delivery to Customer

Assemble & Drive
H1 Automotive Control
SIL 2 Certified H1 AC

Benefits:

- Trusted external audit of product and process by TÜV NORD.

- Required statistical functional safety data available for customers to apply to their application Performance Level.

- Complete application-specific configurable PROPEL-Application

- Plug & Perform by Factory-Calibration
Thank you for your Attention!

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