Technical Information

Propel Application Library (PAL)
Software Function Blocks
### Revision history

**Table of revisions**

<table>
<thead>
<tr>
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</thead>
<tbody>
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<td>Dec 2017</td>
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</tr>
</tbody>
</table>
Contents

Introduction
What is PAL................................................................. 4

Basic Functions
Braking........................................................................ 5
Automotive Creep.......................................................... 5
Creep............................................................................ 5
Basic Drive Curve (modifier)......................................... 6
Drive State machine with FNR + Hold.......................... 7
Engine Control (basic)................................................... 8
Engine Control with Temperature Limitation................. 8
2 pin FNR Switch......................................................... 8
3 pin FNR Switch (push button)...................................... 9
3 pin FNR Switch (held)................................................ 9
Output block 3 pin FNR (LED)....................................... 10
Hydrostatic Core block (basic)...................................... 10
Hydrostatic Core Drive State block............................... 11
Hydrostatic Core block (jump)...................................... 12
Inching function.......................................................... 13
Redundant Pedal......................................................... 13
Pedal........................................................................... 14

Advanced Functions
Command Modifier..................................................... 15
Cruise Control (basic).................................................. 15
Cruise Control with Jog Up / Down............................... 16
ECO Mode................................................................... 16
Hydromotor Overspeed Protection............................... 17
Max Hydromotor Torque Control................................. 17
Stop to Shift................................................................. 18
Temperature Derate..................................................... 18
Vehicle Speed Limitation............................................ 19

Service tool and Documentation

System Builder Sales Tool
General........................................................................ 21
Explanation of cards.................................................. 22
Using the Card Game.................................................. 23
Introduction

What is PAL

PLUS+1® GUIDE allows to implement different software libraries e.g. WFC, PAL. Each library consists of one or more packages which includes different function blocks.

One of the libraries is PAL, which stands for Propel Application Library. Through use of Danfoss PLUS+1® and PAL, you can develop complete propel systems for mobile machinery or easily integrate any PAL function block into your existing propel system — regardless of the system configuration or hardware in use.

PAL not only provides you a competitive advantage by allowing for superior machine performance, but also can dramatically reduce your development time - getting you to market faster. The reason for this is that PAL supports the entire propel software development process, and is aligned with other PLUS+1® compliance blocks.

PAL offers two different library packages.

The "PAL Basic" library package and the "PAL Advanced Power Management (PAL APM)" library package. The PAL basic library package offers a lot of function blocks to design simple propel solutions (e.g. for one pump and one motor). PAL APM library package offers function blocks to get a better driving behavior by "cruise control" or fuel saving by an “eco mode” function block – this means function blocks for advanced features for propel solutions. On the following pages, the function blocks of the former mentioned packages will be explained further to provide a more detailed overview.

PAL function blocks can be used with all MCxx and SCxx Controllers - to use PAL on Application Hardware is not required.

A pre-condition for using PAL is a PLUS+1® GUIDE Professional license (min. version 8.1 or higher) required! PAL will not work with the Guide Express License.

Both PAL library packages can be obtained by a license. The PAL Basic is a free license. The non-free licenses are valid for a limited time and can be renewed by a yearly subscription for each library package. For each function block of the PAL library package, the following documents and software files will be part of the scope:

- PLUS+1® Software Function Block
- Safety Manual and Programmers Guide as .pdf file
- Service Tool Screen as P1D file
- User Manual snippet in MS Word format
Basic Functions

Braking

The Braking function has the purpose of reducing a Drive Command by a Brake Command. Both signals can be read from a lever, potentiometer or pedal. The function can reduce the Drive Command down to complete Stop.

The following diagram illustrates in a simplified way how the function block works:

![Braking Diagram]

Automotive Creep

An Automotive drive Mode uses the engine rpm as the setpoint signal for the drive curves. The engine rpm is measured with a PPU or received via CAN message. This engine rpm signal is virtually reduced by the Creep Command, the setpoint for the drive curves is reduced as well.

With a Creep Command = 100% the Engine Speed In is directly send to the Engine Speed Out signal. By parameter a “minimum Engine Speed out” can be defined. A Creep Command = 0% will reduce the Engine Speed in to the “minimum Engine Speed out”.

This function requires a creep pedal or potentiometer being installed on the machine. The creep signal needs to be prepared as a percentage value (e.g. by using Pedal function block).

The following diagram illustrates in a simplified way how the function block works:

![Automotive Creep Diagram]

Creep

Creeping is a function to scale (reduce) the Drive Command In proportionally.

With a Creep Command = 100% the Drive Command in is equal to the Drive Command out. A Creep Command = 0% will reduce the Drive Command out to 0%. This function requires a creep pedal or potentiometer being installed on the machine. The creep signal needs to be prepared as a percentage value (e.g. by using Pedal function block).

The following diagram illustrates in a simplified way how the function block works.

![Creep Diagram]
Basic Functions

**Creeping**

**Basic Drive Curve (modifier)**

Basic Drive Curve is a function that modifies an Input Drive Command with a 6-point profile. A percentage factor is used to modify the output of the profile. If a stop request is received, the Output Drive Command is pulled to zero. The final output is time-ramped at a rate settable by time rate parameters.

The following diagram illustrates in a simplified way how the function block works.
Basic Functions

Drive State machine with FNR + Hold

The Drive State Machine is a function between a FNR to choose the driving direction and the hydraulic power transmission for driving (pump + hydromotor). The Drive State Machine sets the Direction State based on the request given via Direction Request (FNR). The Start Protection can block the Direction Request e.g. if the engine rpm is too low.

The function Hold Direction can hold (store) the Direction Request if there is a reason not to change the driving direction e.g. vehicle speed is too fast for a safe direction change.

The following diagram illustrates in a simplified way how the function block works.
**Basic Functions**

**Engine Control (basic)**

The Engine Control Basic is a function that converts a Drive Command into an Engine Speed Command and passes the output command through a time ramp. This requires an interface to the diesel engine such as a CAN bus or throttle actuator.

The following diagram illustrates in a simplified way how the function block works.

![Engine Control (basic) Diagram](image)

**Engine Control with Temperature Limitation**

This function converts a Drive Command into an Engine Speed command and passes the output command through a time ramp. If the measured Temperature is below a threshold value the engine speed command will be limited to a parameter value and the output Limited Range will indicate that the engine speed limitation is active. This function block shall be used for generating an engine speed setpoint. This requires an interface to the diesel engine such as a CAN bus or throttle actuator.

The following diagram illustrates in a simplified way how the function block works.

![Engine Control with Temperature Limitation Diagram](image)

**2 pin FNR Switch**

The FNR 2 Switch function block generates a Driving Direction request (Forward, Neutral or Reverse) based on Forward Switch and Reverse Switch. If Forward Switch is active exclusively, the Direction Request will be Forward. If Reverse Switch is active exclusively, the Direction Request will be Reverse. If no switch is active, the Direction Request will be Neutral. If both switches are active for more than Error Delay Time, a fault will be declared and the Driving Direction request output is forced to Neutral.

The following diagram illustrates in a simplified way how the function block works.

![2 pin FNR Switch Diagram](image)
Basic Functions

3 pin FNR Switch (push button)

The FNR 3 Pushbutton function block generates a Driving Direction request (Forward, Neutral or Reverse) based on Forward Pushbutton, Reverse Pushbutton and Neutral Pushbutton. If Forward Pushbutton is active exclusively, the Direction Request will be Forward. If Reverse Pushbutton is active exclusively, the Direction Request will be Reverse. If Neutral Pushbutton is active exclusively, the Direction Request will be Neutral. If no Pushbutton is active the last Direction Request will be kept. If more than one pushbutton is active at the same time for more than Error Delay Time, a fault will be declared and the Driving Direction request output is forced to Neutral.

The following diagram illustrates in a simplified way how the function block works.

![Diagram of 3 pin FNR Switch (push button)]

3 pin FNR Switch (held)

The FNR 3 Switch function block generates a Driving Direction request (Forward, Neutral or Reverse) based on three input signals. The signal must be held (continuously). If Forward Switch is active exclusively, the Direction Request will be Forward. If Reverse Switch is active exclusively, the Direction Request will be Reverse. If Neutral Switch is active exclusively, the Direction Request will be Neutral. If none or more than one switch is active for more than Error Delay Time, a fault will be declared and the Driving Direction request output is forced to Neutral.

The following diagram illustrates in a simplified way how the function block works.

![Diagram of 3 pin FNR Switch (held)]
Basic Functions

Output block 3 pin FNR (LED)

This FNR LED Output block derives three output signals Forward, Reverse and Neutral from the input Driving Direction. It can be used to control direction indication lamps.

The following diagram illustrates in a simplified way how the function block works.

Hydrostatic Core block (basic)

This function block takes an input Drive Command and converts it into a Hydrostatic Command. It allows implementing different drive concepts for pump and motor such as Automotive Control and Non-Automotive Control. The Drive Command can be from various signals. For Automotive Control the drive command will be the engine speed. For implementing a Non-Automotive Control the drive command can be a pedal position or a hydrostatic ratio command. There’s no specific hardware for this function block required. It is recommended that the engine goes to Low Idle instead of High Idle in case of an error (e.g. lost connection).

The following diagram illustrates in a simplified way how the function block works.
Basic Functions

Hydrostatic Core Drive State block

This function block takes an input Drive Command and converts it into a Hydrostatic Command. It allows implementing different drive concepts for pump and motor such as Automotive Control and Non-Automotive Control. The drive command can be from various signals. For Automotive Control the drive command will be the engine speed. For implementing a Non-Automotive Control the drive command can be a pedal position or a hydrostatic ratio command.

Different sets of parameters are used for internal profile and time ramp depending on the actual drive state. The input drive command is automatically forced to zero when the Drive State is at Braking, Reversal, Stop, Parking or an undefined state. So only when drive state is Forward or Reverse the drive command will be forwarded to the corresponding profile. There's no specific hardware for this function block required. It is recommended that the engine goes to Low Idle instead of High Idle in case of an error (e.g. lost connection).

The following diagram illustrates in a simplified way how the function block works.
Basic Functions

Hydrostatic Core block (jump)

This function block is intended to be used for controlling NFPE pumps.

This function block takes an input Drive Command and converts it into a hydrostatic command. It allows implementing different drive concepts for pumps such as Automotive Control and Non-Automotive Control. The drive command can be from various signals. For Automotive Control the drive command will be the engine speed. For implementing a Non-Automotive Control the drive command can be a pedal position or a hydrostatic ratio command.

Different sets of parameters are used for internal profile and time ramp depending on the actual drive state. The input Drive Command is automatically forced to zero when the Drive State is at Braking, Reversal, Stop, Parking or an undefined state. Only when drive state is Forward or Reverse the Drive Command will be forwarded to the corresponding profile.

In this kind of hydrostatic core function block it is possible to perform a jump of the hydrostatic command. The jump feature is useful when implementing an Automotive Control using a NFPE pump. Typically the current controlling a NFPE pump is overdriven to ensure that the pump is at maximum displacement. When triggering a Reversal, Braking or Stop state the pump current will ramp down, but without any vehicle deceleration as long as the pump current is above a machine specific threshold. The jump feature allows skipping this current range by jumping directly to this threshold. There’s no specific hardware for this function block required. It is recommended that the engine goes to Low Idle instead of High Idle in case of an error (e.g. lost connection).

The following diagram illustrates in a simplified way how the function block works.
Basic Functions

Inching function

The Inching signal reduces the drive command. A 0% Inch Signal leaves the drive command unchanged (Drive Command in = Drive Command out). A 100% Inch signal reduces the Drive Command out to 0. The Inch Command can be profiled by an 8 point profile.

The following diagram illustrates in a simplified way how the function block works.

![Inching Diagram]

Redundant Pedal

The Redundant Pedal function block converts a voltage signal from a pedal into a percentage output. This percentage output is based on the signal characteristics of the sensor. A built-in calibration routine can capture the electric signal at each end of the sensor’s range. This function block scales its output between 0% and 100%. It also uses a redundant pedal signal input to monitor if the nominal signal works well.

The following diagram illustrates in a simplified way how the function block works.

![Redundant Pedal Diagram]
Basic Functions

Pedal

The Pedal function block converts a voltage signal from a pedal into a percentage output. This percentage output is based on the signal characteristics of the sensor. A built-in calibration routine can capture the electric signal at each end of the sensors range. This function block scales its output between 0% and 100%.

The following diagram illustrates in a simplified way how the function block works.
Advanced Functions

Command Modifier

The Command Modifier function block is used to modify a command signal by adding adjust value. This could be a different control functions (e.g. Motor Overspeed Protection, Engine Overspeed Protection, Speed Limiter, Antistall…).

Furthermore the Command Modifier function block calculates a hold signal for each of the control functions. The hold signals allow to hold the adjust value of a control function with a lower priority at its momentary value if another control function with a higher priority becomes active (adjust value no longer zero).

The following diagram illustrates in a simplified way how the function block works.

Cruise Control (basic)

The Cruise Control function stores (freeze) the Drive Command value (vehicle speed) when activated. The cruise operation can be deactivated and resumed.

The following diagram illustrates in a simplified way how the function block works.
Advanced Functions

Cruise Control with Jog Up / Down

The Cruise Control function stores (freeze) the Drive Command value (vehicle speed) when activated. The cruise operation can be deactivated and resumed. The stored value can be increased or decreased in steps.

The following diagram illustrates in a simplified way how the function block works.

ECO Mode

An ECO Mode is used to drive the vehicle with reduced engine rpm at the maximum vehicle speed. The hydrostatic driveline need to be oversized (faster) to be able to reduce the engine rpm.

The Drive Command (e.g. from the drive pedal) creates the Engine Speed Command. If the ECO Mode is enabled but not active, then PI controller of the ECO Mode function serves as a speed limiter. When a certain vehicle speed is reached and maintained for a defined time, the ECO Mode will be activated and reduces the engine speed automatically. Then the PI controller works as a constant speed drive (CSD). The pump displacement must in turn be increased to keep the vehicle speed on the same level with a reduced engine speed.

The ECO Mode is automatically switched off (inactive), if the vehicle slows down, the Drive Command (pedal) drops or the Drive State is changed.

The following diagram illustrates in a simplified way how the function block works.
Advanced Functions

Hydromotor Overspeed Protection

The function block compares the actual hydro motor speed with the parameter value for maximum allowed speed. If actual speed is below maximum speed the hydro motor Overspeed Adjust will be zero. If actual speed is above maximum speed the function calculates a negative overspeed adjust value. This value is later applied to another command (e.g. pump or hydro motor command depending on the used components) to reduce the hydro motor speed.

The following diagram illustrates in a simplified way how the function block works.

Max Hydromotor Torque Control

The Max Hydromotor Torque block will command the Hydromotor to max displacement until a defined vehicle speed is reached. This will provide the max torque/tractive force when starting from stop. The Hydromotor command for the drive profile will be overwritten as long as the function is active.

The following diagram illustrates in a simplified way how the function block works.
Advanced Functions

Stop to Shift

The Stop to Shift function block prevents gear shifting if vehicle speed is too high. It holds the last gear command at the output as long as the vehicle speed is above the parameter „Allow Shift Speed“. If the vehicle speed is below the parameter value and Enable input is true then the requested gear command is forwarded.

When starting the microcontroller the gear command at the output is set to a default value, defined by parameter.

This function requires a gearbox which can only shift in standstill.

A fault of the PPU used for measuring the vehicle speed can cause shifting at too high speeds. If the PPU has a fault detection then this could be used to suppress the shifting.

The following diagram illustrates in a simplified way how the function block works.

Temperature Derate

The Temperature Derate block modifies an input command by multiplying it by a percentage temperature factor. This factor is derived from a temperature input feeding into a 6-point profile. A Time Ramp is used directly on the profile output to smooth the result of any steep-sloped profiles. If the function becomes inactive, the input command is passed straight through by multiplying by 100%. The purpose of this function is to protect your system when it is too hot or too cold.
Advanced Functions

Vehicle Speed Limitation

The Vehicle Speed Limitation compares actual Vehicle Speed with Max Vehicle Speed in Forward and Reverse direction. Depending on the selected driving direction one of the limits is used. If the Limit is reached a correction signal (Speed Limit adjust) is modified. This value is intended to limit the vehicle speed by applying it to another command (e.g. drive command).

The following diagram illustrates in a simplified way how the function block works.
Example: Braking
Screen 'Braking'
Select the 'Braking' screen.
*This screen gives an overview of adjusting the Braking function.*

The Braking function has the purpose to reduce a Drive Command that is read from a lever, potentiometer or pedal by a braking signal that is given by another input. The function can reduce the drive setpoint down to zero if a Stop Request is set by another function.

<table>
<thead>
<tr>
<th>Description</th>
<th></th>
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<tbody>
<tr>
<td>Drive Command In</td>
<td>The command for driving. Drive command comes from a foot pedal, lever or potentiometer.</td>
</tr>
<tr>
<td>Brake Command</td>
<td>The command for decreasing driving speed. Brake command comes from a foot pedal, lever or potentiometer.</td>
</tr>
<tr>
<td>Stop Request</td>
<td>Digital (Boolean) input signal. Stop request command. 1 (True): Perform Braking regardless of the Brake Command input 0 (False): Normal action</td>
</tr>
<tr>
<td>Limit Input</td>
<td>Signal after subtraction and switch, input to the limitation.</td>
</tr>
<tr>
<td>Drive Command Out</td>
<td>Modified Drive Command.</td>
</tr>
<tr>
<td>Fault</td>
<td>This signal indicates if an input fault is declared. It’s a bitwise code, so multiple items can be reported at a time. The following fault codes are provided: 0x0000: No fault 0x8002: Drive Command In/Brake Command value is/are too high</td>
</tr>
<tr>
<td>Material Number</td>
<td>Material/identification number of the overall software application.</td>
</tr>
<tr>
<td>Software Version</td>
<td>Software version number of the overall software application.</td>
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</tbody>
</table>

Start-up Procedures
There is no particular start-up procedure needed for this function.

Fault Analysis
If Drive Command In or Brake Command is greater than 100.00% then Fault displays 0x8002 and Drive Command In or Brake Command is clamped to 100.00%.
The PAL System Builder Sales Tool is a kind of card game to support the visualization of propel software solutions with PAL function blocks during the design phase of the propel software development process.

One deck of cards of the System Builder Sales Tool consist of:
- in total of 61 cards incl. one instruction card
- 37 software function blocks of the PAL Basic and PAL APM library package
- 12 blank cards for customized functions (4 of each color)
- 11 compliance block cards (4 motor driver, 4 pump driver, speed and pressure sensors)
Explanation of cards

4 different library packages: (Basic) Basic & (APM) Advanced Power Management cards are available! (MM) Multi-Motor & (DuPa) Dual Path cards will follow after finishing their development.

4 different function block groups: Only important for software developers to find the selected function block easier in the library – same symbols at the library for Front Add-on, Engine Core, Hydrostatic Core, Rear Add-on.

4 different card types (1x compliance 3x function blocks): GREY = compliance blocks BLUE = input fct. blocks YELLOW = function blocks ORANGE = output fct. blocks

Naming of function block (1 card = 1 function block) e.g. „Hydrostatic Core“ is the name of this function block and describe main function shortly, but some are available with different subfunctions like here „Drive State“. It is also a „Hydrostatic Core“ fb available as „Basic“ or „DS w. Jump“

Hydrostatic Core
Drive State

Blue area = Input signals which are necessary for this fb
Yellow area = Short description of the function of the block
Orange area = Output signals which the function block delivers

This symbol shows that this function block is part of the „Basic“ library package. So the software developer needs to get this fb for his propel software solution.

This symbol is a group symbol and stands in this case for the „Hydrostatic Core“ group. This allows the software developer to find this function block very easy in the library. Other group symbols are like Front Add-on, Engine Core or Rear Add-on.
Using the Card Game

The best way is to take a white sheet of paper to lay the function block cards on it or a white board to stick the cards on it.

At first it makes sense to connect the Danfoss products like a motor, pump or sensor with the compliance blocks as also the remaining sensors like FNR switch or braking lights with the controller – “bring the sensors and actors in the controller”. Now, select the necessary PAL function blocks as card stick or lay them on the paper which should show the memory of the controller and connect the PAL function blocks and compliance blocks with drawn lines. If a function block is not available in the deck of cards of the PAL System Builder Sales Tool it is possible to use one of the blank function block cards and write (with a non-permanent pen) a specific name on it, add it to the paper.

This procedure helps to have very fast a first picture of the software design on the paper – make a photo and the next step of the software development can start in PLUS+1® GUIDE with PAL:
Danfoss Power Solutions is a global manufacturer and supplier of high-quality hydraulic and electronic components. We specialize in providing state-of-the-art technology and solutions that excel in the harsh operating conditions of the mobile off-highway market. Building on our extensive applications expertise, we work closely with our customers to ensure exceptional performance for a broad range of off-highway vehicles.

We help OEMs around the world speed up system development, reduce costs and bring vehicles to market faster.

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Go to www.powersolutions.danfoss.com for further product information.

Wherever off-highway vehicles are at work, so is Danfoss. We offer expert worldwide support for our customers, ensuring the best possible solutions for outstanding performance. And with an extensive network of Global Service Partners, we also provide comprehensive global service for all of our components.

Please contact the Danfoss Power Solution representative nearest you.