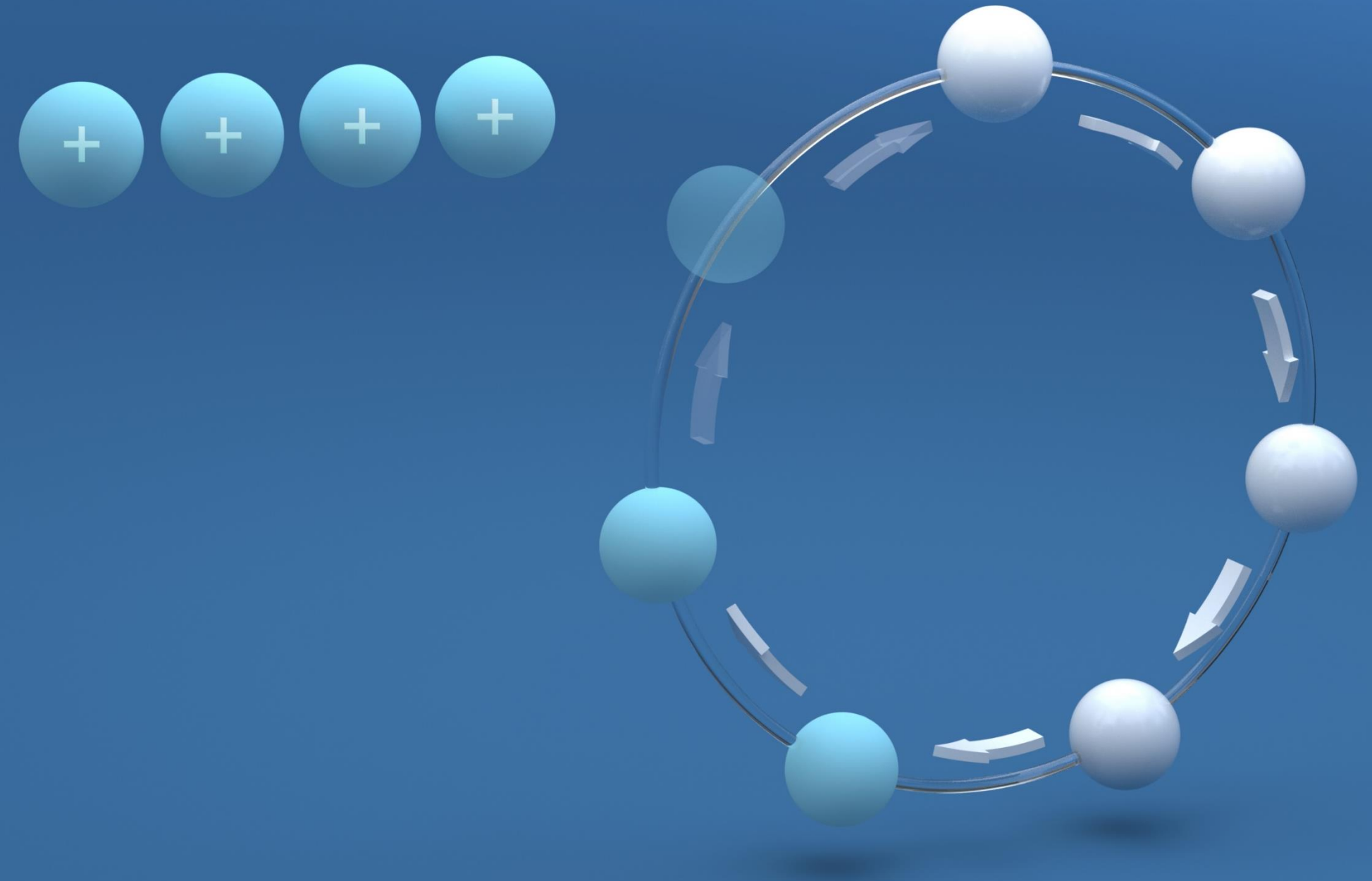


# ARADEX – Technology Modules Portfolio

We drive new energy for a greener future



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\* COMING SOON

# / Added values for your applications

## Using technology modules in inverters and DC/DC converters

**We believe that functions will become the main driver for the electrification of drivetrains in mobile working machines.**

- In the 1960's we saw a disruption in mobile working machines by “**hydraulification**” of the working processes. The improved control of force and movement enabled new functions and easier usage of the machines. We expect new “**electrification**” to cause similar disruption.
- A main cornerstone will be to use the inverter-motor combination as its own torque-sensor. And to use the perfect control to create new or greatly improved functionality of the working machines.
- Some of these new functions can be realized using the vehicle controllers, this is common technology in NC based production machines for example. But there are many functions which could be realized using technology modules inside the inverters and DCDC converters, because the real-time coupling of acting and sensing opens doors for new technology.
- In this presentation we want to give an overview about the new possibilities we can offer for your applications.

# / MultiDeviceAnalyser

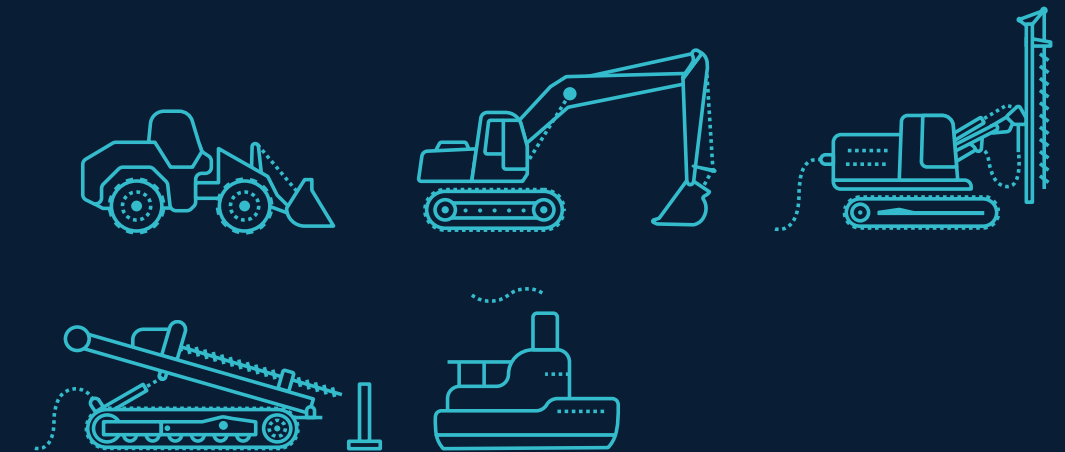
## Overview

"VECTOPOWER goes system": The MultiDeviceAnalyser function saves data of the internal oscilloscope function synchronous on multiple VECTOPOWER devices. A critical error or a command triggers data-saving on all VECTOPOWER devices on the same CAN bus. The function can be implemented in VP600 inverters Series2 and Series3 as well as in VP5000 DC/DC.

## The benefits

The Analyser function can be parameterized on each device individually, including sample rate and pre-trigger. Because it's realized using a high priority function of the CAN, the overall maximum jitter-time between all Analyser-files is only a few ms. In the event of an error or special operation condition on one device all relevant variables of all VECTOPOWER devices in a common HV system can be made visible.

## Application areas

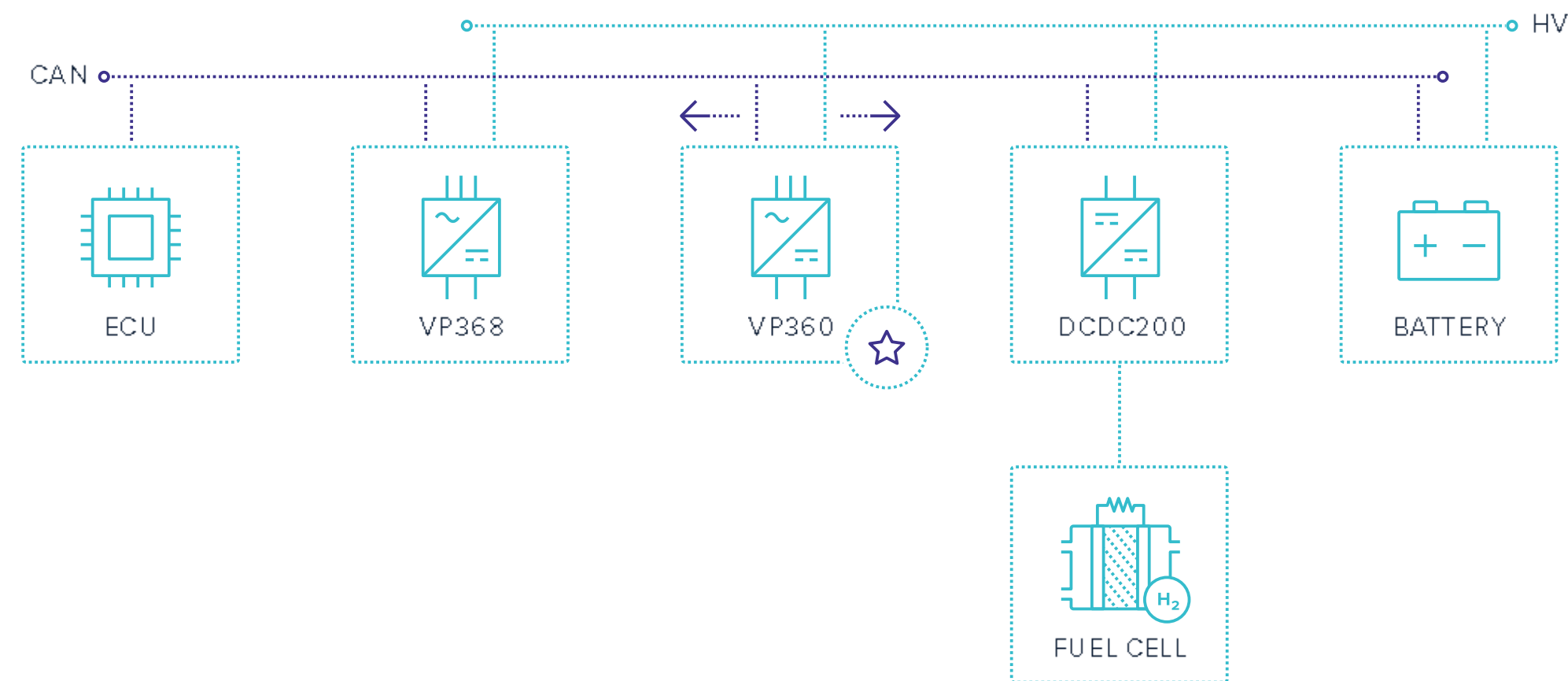


- For all systems with more than one VECTOPOWER device.
- Especially suitable for diagnostics of power management of complete HV system.

## How Multi-Device-Analyser works

"The MultiDeviceAnalyser function saves data of the internal oscilloscope function synchronous on multiple VECTOPOWER devices.

The schematic diagram below shows us an example:



- "The VECTOPOWER VP600 inverter of an auxiliary drive (marked with a star) detects an effect which must be logged with Analyser-file. For example, VP600 detects a short overvoltage situation on DC-HV.
- The VP600 relays this occurrence to all connected HV devices via CAN message (arrows). In this example to a VP600 for propulsion and to a DCDC which is connected to a fuel cell.
- The info is also relayed to the connected ECU, which can then collect all Analyser-files from all VP devices and make it available for subsequent diagnostics.

# / SmartDC

## Overview

In distributed HV systems with several participants on the same DC line a major challenge is a smart solution of the overall power management. Real-time reaction is needed to realize the power management. The SmartDC function solves this in a robust and reliable way and does not require a real-time bus communication. The function can be implemented in VP600 inverters Series2 and Series3 as well as in VP5000 DC/DC.

## The benefits

Instead of controls based on any kind of real-time bus communication, ARADEx SmartDC takes the HV DC voltage itself as "information-source" and can react within times well below 1ms if necessary. Thus, a short black-out of bus communication has no impact on a stable control of power and high voltage. In SmartDC the CAN is used only to modify parameters or exchange information. Depending on the total solution, even third-party HV-devices can be taken into account and managed in operation of voltage and power control.

## Application areas

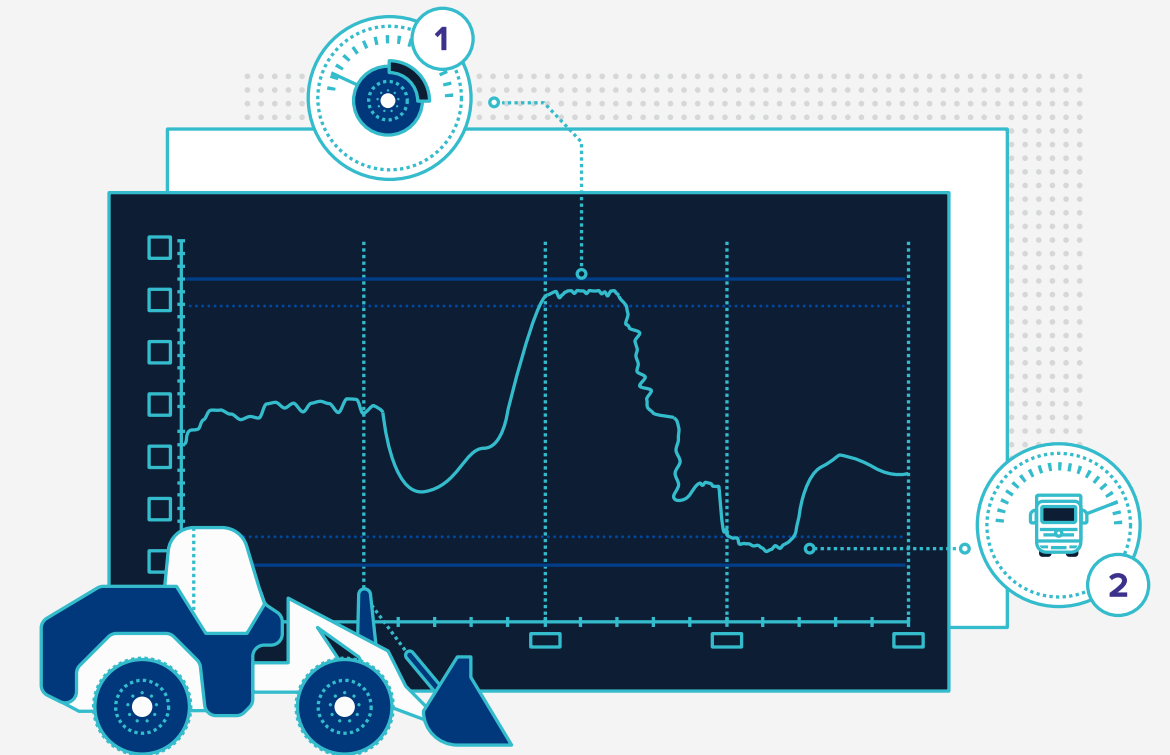
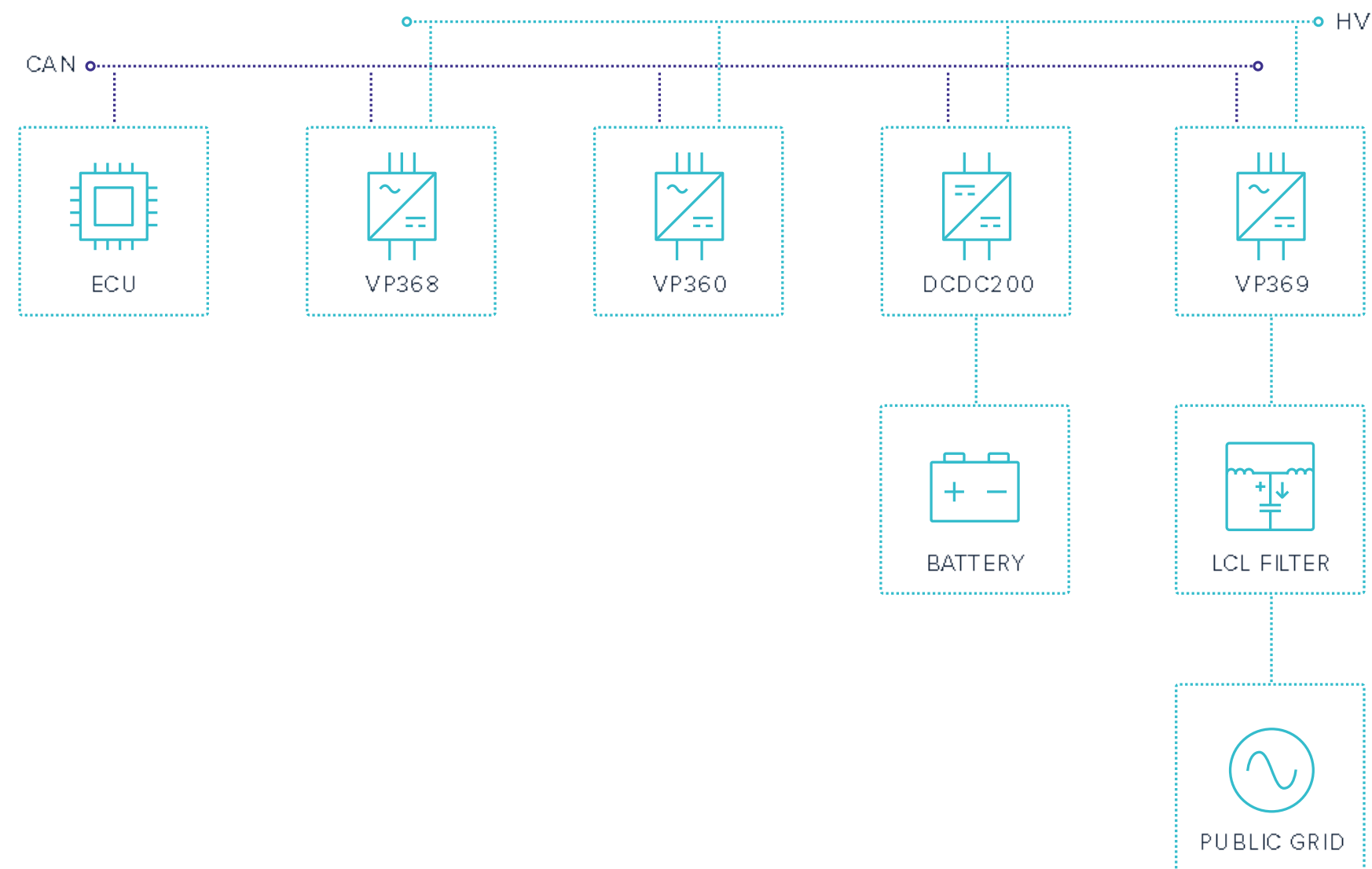


Specifically for HV systems with parallel working energy suppliers and energy consumers:

- Cable-supplied machines
- Serial hybrids
- Fuel cell systems

## How Smart-DC works

This example shows a wheel loader powered by public grid and with an additional battery for power-shaving. The battery supplies peak power and enables recuperation of energy. In this example we have a VP600-18W368 for propulsion, a VP600-18W360 for hydraulic pump, VP5000-DCDC200 for connecting the battery and a VP600-18W369 for the AFE-connection to grid.



**(1):** High power recuperation nearly exceeds the maximum power we can feed into the battery -> we must limit recuperation

**(2):** High power demand nearly exceeds the maximum power from battery and grid -> we must limit the power

# / AnalogInput

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## Overview

Use of analog input signals for real-time control of customized functions. Available for VP600 inverters Series2 for marine applications. For example, for communicating the set speed of the propeller drive from the central controller to the propulsion inverters.

For high redundant systems parallel and compared communication by CAN and AnalogInput can be realized.

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## The benefits

For example, as set-values. 2 possibilities: 0...10V and 4...20mA. Can be used for ship propulsion as a second channel in addition to CAN communication.

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## Application areas



- Mainly for marine propulsion as redundant communication.
- Set values are transmitted parallel by CAN and analog.



# / MasterSlave

## Overview

Up to 5 VECTOPOWER inverter-motor-packs can be synchronized to work in parallel operation. For implementing high power drivetrains with paralleled e-motors. The function can be implemented in VP600 inverters Series2 and Series3.

## The benefits

Typical applications are high-power drivetrains where 2, 3, 4 or 5 e-motors are connected to a summation gearbox to work together. Example: continuous power up to 1200kW (peak more than 2000kW) with 4 synchronized motors is possible. Another use is to operate 6-phases motors with phase-shifted phases with a double VECTOPOWER inverter (for example VP600-18W344).

## Application areas

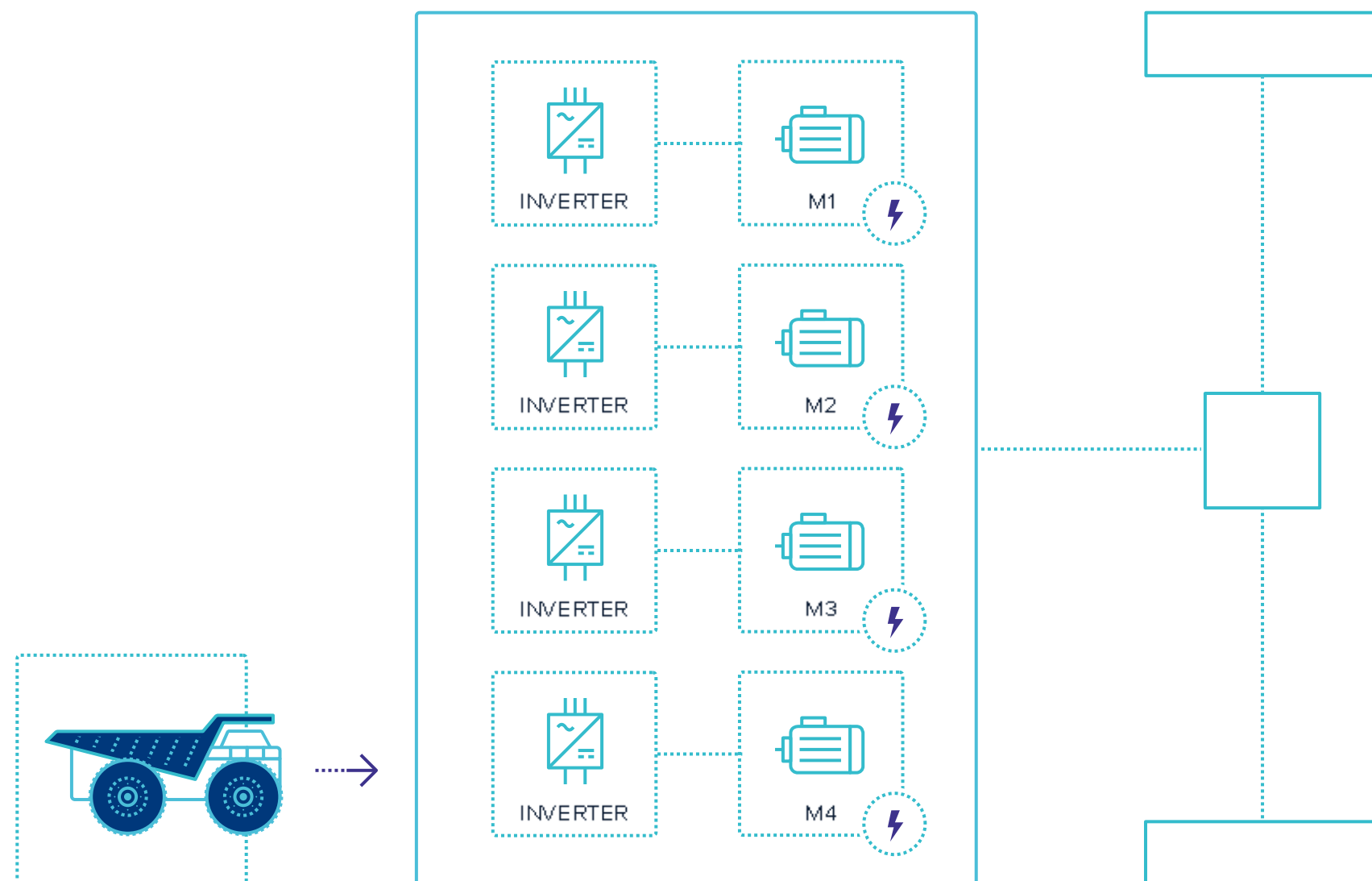


For high power drivetrains with more than 300kW continuous power:

- Large dumpers
- Harvesters
- Large drilling machines

## How Master-Slave works

This example shows a high-power propulsion offering around 1200kW continuous power for a big dumper. To realize such high power, we couple 4 e-motors with a summation gearbox. The VP600 inverters synchronize themselves and can be operated like one single 1200kW drivetrain.



## Your advantages

If we take 4 AC-induction motors, we have an additional advantage: a perfect redundancy. If one motor or inverter is defect, we can use the remaining 3 motor-inverter sets to move the vehicle. The defective motor or inverter will not cause an unwanted braking torque or unwanted generated voltage. Because AC-induction motor will run idle without torque even in the event of a short circuit in inverter.

# / SmartShortCircuitBraking

## Overview

For limiting the braking torque when using the function "ActiveShortCircuit" for example: in the event that the bus-communication malfunctions. If an all-phases-short-circuit is applied to a pm-reluctance motor as used for traction drives, the braking torque strongly depends on the speed of the motor. At higher speed levels the braking torque is very low. But at lower speed the braking torque increases and can be too high for some dedicated applications.

The SmartShortCircuitBraking function allows use of the active short circuit in a defined speed range to avoid excessive braking torque. The function can be implemented in VP600 inverters Series2 and Series3.

## The benefits

With this function it is possible to use PM or PM-reluctance motors for braking function outside and in addition to the normal 4Q-operation. When the control is switched "off" then active short circuit starts. And this short circuit is limited to work inside a parameterized speed range.

## Application areas



For applications where the short circuit function of VP600 inverter is needed as a redundant fallback function and simultaneously the braking torque must be limited.

# / SlipAvoidance

## Overview

Anti-slip control of propulsion drive in starting and acceleration mode. This function takes all necessary information from internal signals of VECTOPOWER inverter and does not need any additional sensor. Slip-Avoidance detects unwanted rising speed of the traction drive and sets some smart limits, thus limiting the unwanted excessive slip.

The function can be implemented in VP600 inverters Series2 and Series3.

## The benefits

This function does not need any additional sensors but works with the VECTOPOWER inverter-motor-set as is. Applicable for off-highway and on-highway applications.

## Application areas



For all kind of wheel-based propulsion drives:

- Dumpers
- Wheel loaders
- Trucks
- Buses

# / AutomaticFieldWeakening

## Overview

This function makes a slight field weakening available for pure PM motors with surface mounted magnets. Easy to apply. This module is made to be used with pure PM-motors (PM motors with surface-mounted magnets) such as those used in various auxiliary drives. When no detailed motor parameters are available this module allows the motor to be used with a small ratio of field-weakening to operate at higher than nominal speed with reduced torque.

The function can be implemented in VP600 inverters Series2 and Series3.

## The benefits

Costly test bench calibration is no longer required, and you have a solution which allows you to operate PM-motors at about 30-40% higher than nominal speed. Depending on your application, this kind of power-spreading can improve the overall performance. For example, for driving hydraulic pumps with higher speed at low load.

## Application areas



Using our auxiliary motors for operating hydraulic pumps for example.

# / DynamicParameterAllocation

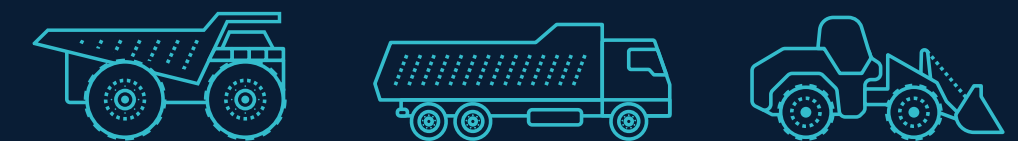
## Overview

The DynamicParameterAllocation DyPA is a sector-based 2-dimensional parameterized adaption of PWM-frequency and control-parameter of the current control in inverter. This specific function increases possible peak-current at low speed of the motors. The function can be implemented in VP600 inverters Series2 and Series3.

## The benefits

The phase current must be derated at electrical frequencies below 20Hz due to semiconductor-effects. The current then can be increased again by lowering the PWM frequency. A low PWM frequency on the other hand, is not feasible for higher motor speeds. To find the most suitable working condition the DyPA can be adjusted 2-dimensionally. Another benefit is the possible reduction of peak-temperature of the IGBT chip, thus improving the lifetime in cyclic load operation.

## Application areas



For all kinds of wheel-based propulsion drives.

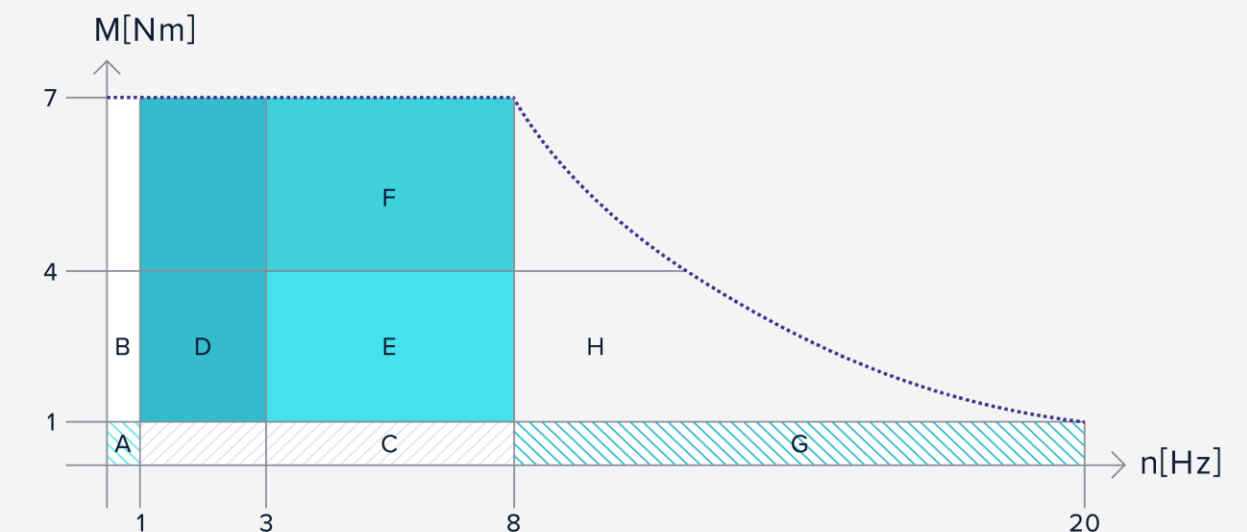
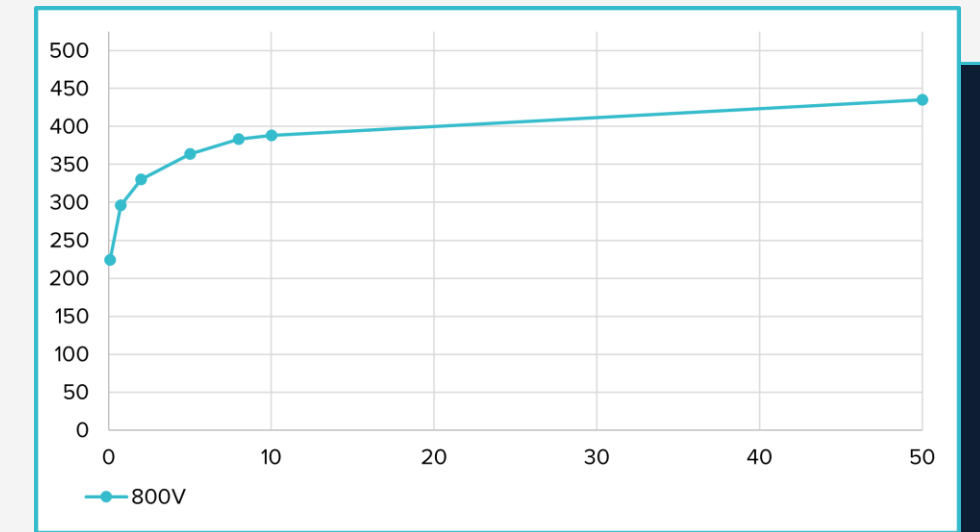
## How DynamicParameterAllocation works

Given by physics of the semiconductors of 3-phase inverters, the possible phase current at very low rotation frequency is reduced in comparison to higher speed. At zero speed we have less than 50% of current in comparison to nominal speed of most applications. The blue curve shows typical values for possible phase current in Arms, depending on the electric rotating frequency in Hz of a VECTOPOWER inverter operating a PM-reluctance traction motor.

If we lower the PWM frequency we can increase the possible current. For example, at 1kHz PWM and zero speed we can increase the current by 40-50% in comparison to 4 kHz PWM. But we only need this lowered PWM if there is high torque demand and not if we just run the vehicle in flat area. For this reason, DynamicParameterAllocation works 2-dimensionally, dependent on speed and torque demand.



## PWM 4kHz



In real applications we can increase the starting torque of vehicles by about 40%!

# / ShortCircuitOnOvervoltage

## Overview

Using PM-reluctance motors with a high field-weakening factor, active short circuit function is required if the motor control malfunctions in order to avoid overvoltage in the system. The additional function ShortCircuitOnOvervoltage allows application of the short circuit depending on the real DC voltage of the HV system.

The function can be implemented in VP600 inverters Series2 and Series3.

## The benefits

VP600 activates this active short circuit by a parameter. The add-on technology module "SmartShortCircuitBraking" allows use of this function in a more dedicated way. Specifically, to avoid the active short circuit in lower speed area where overvoltage is not a given problem, but unwanted brake-torque can be much higher than in a higher speed area.

## Application areas



For special-purpose applications only.



# / BrakeChopper

COMING SOON

## Overview

This function uses VP600 inverter to create a fast reaction and powerful brake chopper. The inverter is connected to the HV-DC as usual. Instead of connecting an electric motor to the 3 phases, bleeding resistors can be used to convert electrical power to heat.

The function can be implemented in VP600 inverters Series2 and Series3.

## The benefits

The external chopper resistors can be connected to the 3-phase-output of inverter. The reaction time is below 1ms. The power depends on the bleeding resistors and the VECTOPOWER model. And for extreme high power, several VECTOPOWER inverters can be operated in parallel. Several control modes are available and can be set as parameters. This module can also be used to create a parametrized power to a resistor, for example as a heating system.

## Application areas



For example, as a "third brake" in big trucks.

# / Contactor Aging Monitoring

COMING SOON

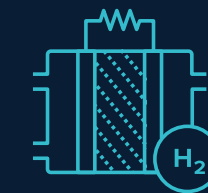
## Overview

For monitoring the wear of the power relays inside VP5000-DC/DC200 and the upcoming FCDC-models.

## The benefits

Counts contactor actions during operation and based on this information estimates the SOH (State-Of-Health) of the contactor. For estimating remaining lifetime and to avoid unplanned system downtime.

## Application areas



Fuel cells with VP5000-DCDC200HL.

# / External Precharge

COMING SOON

## Overview

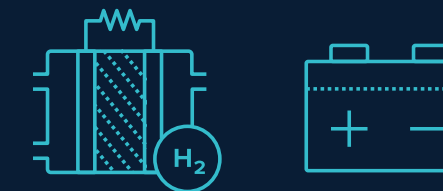
For starting a HV-system to ramp-up the DC voltage with use of external precharge-resistors. The function is realized inside the integrated PLC of the VP600 inverters and VP5000 DCDC. A digital I/O (24V level) is set to switch an external relay and thus to switch a precharge resistor and main power.

This function is available for VP5000-DCDC200, VP5000-DCDC60. VP600-18W361, 369, 345 . The function is already integrated in the VP5000-DCDC200HL.

## The benefits

The function uses the VP600 or VP5000 internal PLC-function for real-time control. And uses the integrated measurement of HV-voltage and the digital I/O to switch the relay for resistors.

## Application areas



For large and complex HV systems.

# / OnePedalDrive

COMING SOON

## Overview

For off-highway-applications only, such as wheel loaders. The acceleration pedal is used for acceleration and electric braking.

The function can be implemented in VP600 inverters Series2 and Series3.

## The benefits

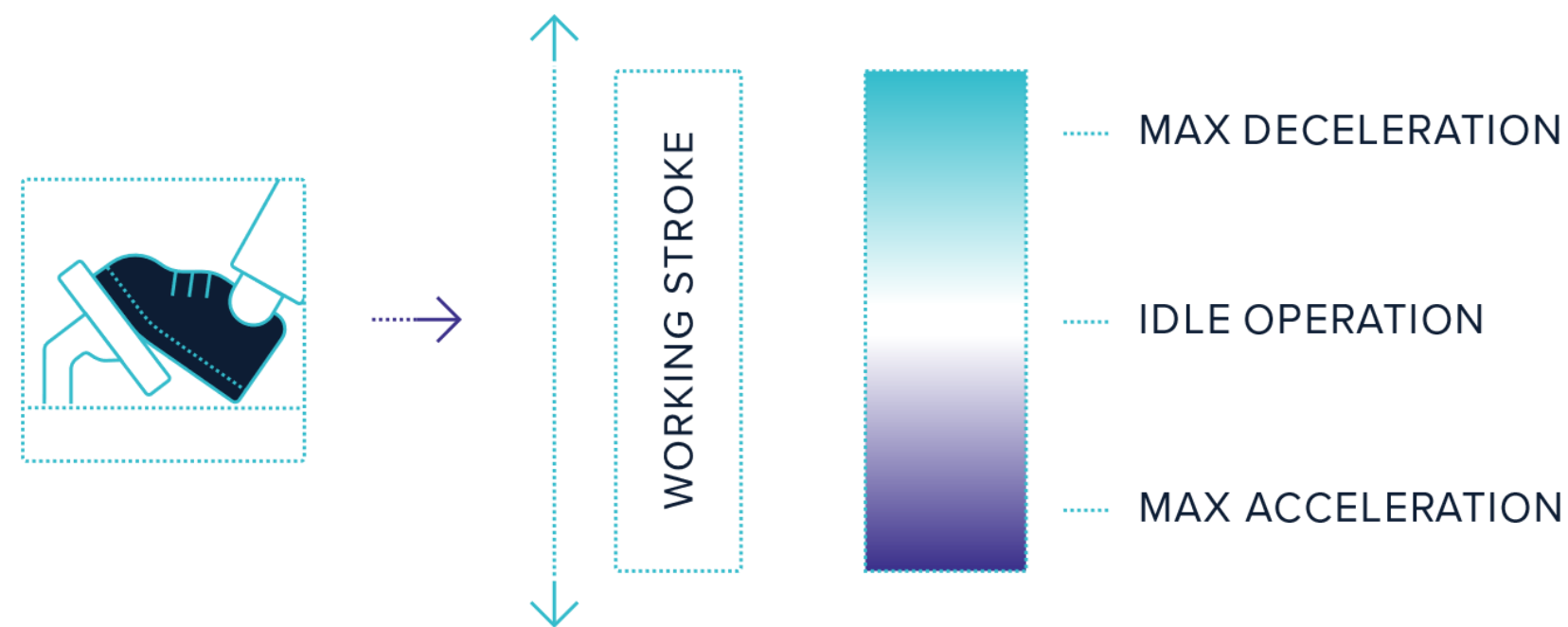
This function is similar to that used in modern battery electric cars. The upper part of the stroke of the acceleration pedal is used for braking and the lower part is used for acceleration. This makes the operation of the vehicle easier and, at the same time, more energy efficient.

## Application areas



Especially for wheel loaders.

## How OnePedalDrive works



Just by using the acceleration pedal of the vehicle or mobile machine the driver can accelerate and decelerate infinitely variably.

- This makes driving easier, especially if we combine the limits for acceleration and deceleration with the driving condition of the vehicle, which is measured by special sensor for incline, acceleration, gyro...
- And the recuperation function becomes more efficient

## Performance and economics

- Makes machines and vehicles easier to drive.
- Improves dynamic traction and thus improves performance of the machine or vehicle.
- Improves efficiency by perfect transition between acceleration and deceleration without delay
- Can be combined with SlipAvoidance to improve drivability and wear of tires.



# / AFE\_Boost

COMING SOON

## Overview

Enables use of the AFE-function with boost function for short time overload in both directions. This function can be implemented in VP600 inverters VP600-18W361, 369, 345. AFE\_Boost is an upgrade-function and requires dedicated VECTOPOWER AFE-hardware (inverter plus specially designed filters) with integrated function AFE as basis.

## The benefits

Add-on module to AFE-function. The capability to make overload usable for the application. The overload capability can be defined by parameters and can be defined depending on the direction of energy-flow. For example: the overload of push-back power into grid can be less than taking power from grid. The parameter setting allows easy adaptation of several limiting factors.

## Application areas



AFE\_Boost is beneficial for all mobile working machines which are mainly supplied by a grid connection.

# / Challenge us

## Review of your application

**Challenge us with your application, your demands and your ideas!**


- + Our engineers can implement or support the project planning for your application.
- + You receive the result as an electronic document: cornerstones of your project regarding electrification or hybridization including dimensioning done by our experienced project engineers.
- + Contact our sales team for more information.

Thanks for your attention!


**Optimized usability  
and performance  
for the best e-mobility**



**Challenge us with your application!**

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