

Product Description and Data Sheet

The PowerStore is a compact, versatile and robust electrical energy storage device. Its main purpose is to stabilise power systems to increase renewable energy penetration and quality of supply. This document contains the Product Description, explaining the main PowerStore components and control functions, as well as Data Sheets for each model.

PowerStore combines an 18 MW-second low-speed flywheel with two solid state IGBT based inverters to provide a compact, robust, reliable and high-performance grid stabilising device.

PowerStore is able to sink or source energy up to its nominal power rating. PowerStore is also capable of responding to power system changes, with a response time of approximately 5 ms.

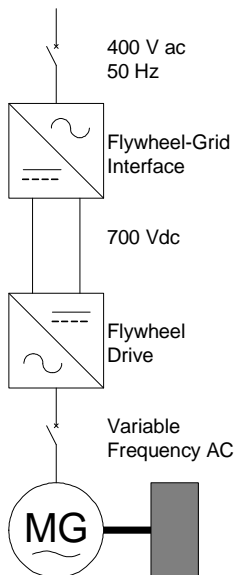


Figure 1 - PowerStore Single Line Diagram

The PowerStore consists of the following four main components:

- Container Building
- Flywheel Spinning Mass
- AC-DC-AC Converter System
- Control and SCADA System

CONTAINER BUILDING

All of the components are conveniently factory installed into a 40 foot shipping container, requiring a minimum of installation on-site. Air conditioning is installed at one end of the container provide cooling for the flywheel and converter system.

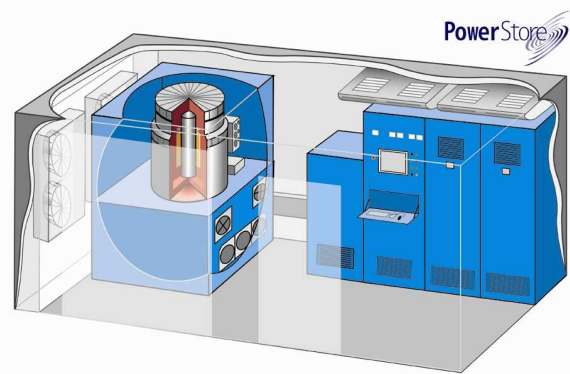


Figure 2 - Flywheel Installed within the containerised building

Figure 2 displays the arrangement of the main PowerStore components. On the left can be seen the flywheel with the air-conditioning system mounted behind. On the right are the Control System and Converter System switchboards.



Figure 3 - PowerStore 500kW Container Outside view

Figure 3 shows the PowerStore container building of a PowerStore 500 from the outside. The purpose built container has a roof for sun and rain protection. The personal access door is open in the above picture.



Figure 4 - Control Cabinet with SCADA Screen, inside of container

Figure 4 shows one person working on the SCADA Screen and the second person behind on the flywheel.

Two three phase power feeds (one for the main power attachment, the other for auxiliary components including the cooling system) and some basic control wiring are all that is required for electrical connections. As a result the installation on site can be completed within days.

The isolation of the system can be undertaken through lockable isolators separating the PowerStore from the mains supply.

Flywheel Spinning Mass

The selection of flywheel has been made considering reliability in service. The machine manufactured by Piller in Germany has been on the market for approximately 7 years and there are in excess of 700 units installed in UPS applications operating 24 hours a day 7 days a week around the world.

This unit rotates at a rated speed of 3,600 RPM and uses a pressurised helium environment to reduce frictional losses. The unit has a lifting magnet that holds the weight of the 3,000 kg flywheel during operation, ensuring a long life, reduced losses and low maintenance. Power for the lifting magnet is derived from the generator mounted on the flywheel shaft, allowing the lifting magnet to be fully functional whenever the flywheel is spinning at operational speed – even if supply power is removed from the machine.

Oversized primary mechanical bearings are also included to hold the weight of the flywheel while it is stationary and below operational speed.

In the event of a primary bearings and lifting magnet failure, catch bearings are installed to carry the weight of the flywheel while it is stopping, providing a fail-safe system.

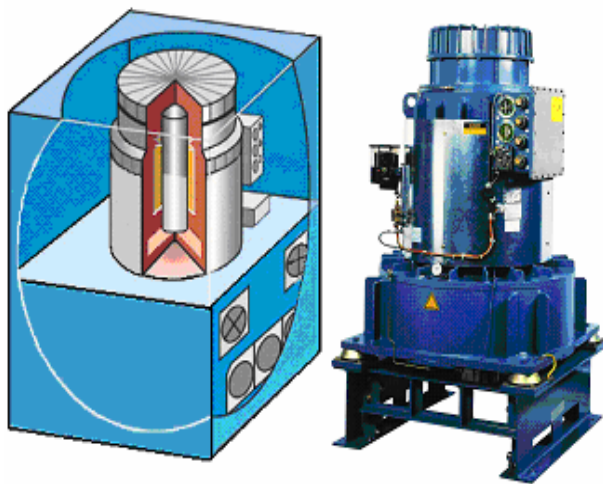


Figure 5 - Flywheel

The flywheel requires a preventative service inspection once per year. The unit has an automatic greaser installed which needs to be refilled every 5 years. Helium is provided from a source bottle that requires replacing typically after three years. There are no other items that require regular maintenance.

AC-DC Converter System

Custom control software has been developed in Australia, to create a high performance IGBT based Flywheel Grid Interface as well as Flywheel Drive. The hardware is based on standard power conversion modules used for Variable Speed Drives and other Power Quality Products. Using these proven modules results in a highly reliable design through an installed base of thousands of units worldwide.

The use of two IGBT inverters, connected via a DC bus allows the flywheel to rotate at a speed that is independent of:

- Grid frequency
- Grid voltage
- Power export/import

This also allows the PowerStore to export and import at maximum power ratings regardless of the energy stored, from 0% to 100% capacity. There is no need to de-rate the PowerStore at lower energy levels.

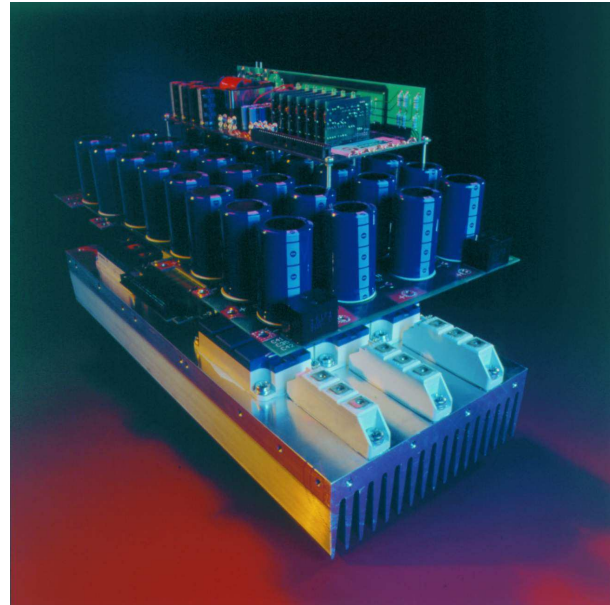


Figure 6 - IGBT Inverter Module used for PowerStore

The Flywheel Grid Interface inverter is also capable of delivering power during brown-out events by increasing the output current until the current limit of the inverter is reached.

The DC Bus can also be fitted with a dump load to prevent the flywheel from “over-filling”. This is most useful in renewable energy systems where the available energy to discharge determines how efficiently the hybrid system can be operated.

Control and SCADA System

PowerStore has been designed for remote unsupervised operation. Apart from the yearly service inspection of the equipment there is no need to attend the system.

An advanced SCADA and Control System monitors and controls the flywheel and converter components to achieve safe and reliable operation, provide data recording and remote access. Data recording is provided at two levels, a high resolution (down to 100 ms) recording system for fault finding and a low resolution (10 minute) recording system for performance and financial analysis.

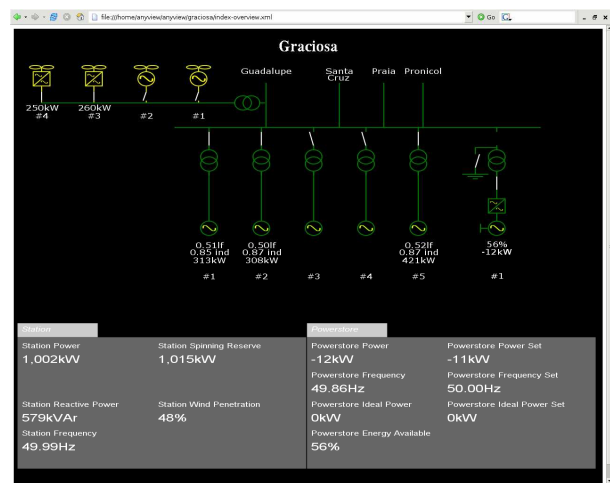


Figure 7 - PowerStore Wind Diesel SCADA Screen

A number of variables are recorded in the SCADA system such as

- PowerStore Power
- PowerStore Energy Level
- Mains 3-phase Voltage
- Mains 3-phase Currents
- Flywheel, Container and Inverter Temperatures
- Alarms, Status and Operation Mode
- Next PowerStore Service time

In addition, this data can be exported into a wide range of software, include Microsoft Excel for further analysis.

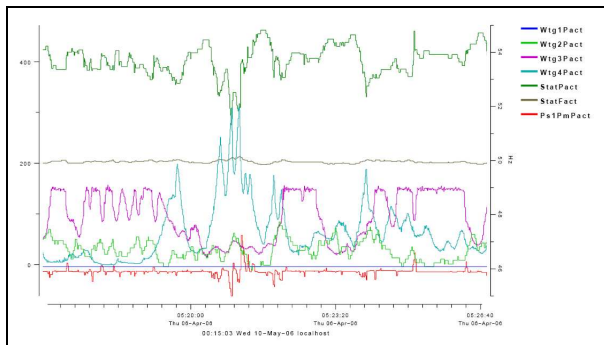


Figure 8 - PowerStore Data Recording Trending Screen

The PowerStore can be remotely started and stopped and alarms remotely monitored. These can also be remotely reset.

The control cabinet houses a local interface for control, as well as a local touch screen for status information and diagnosis (see Figure 4 - Control Cabinet with SCADA Screen, inside of container). All of the information available locally is also available remotely, across data links including Ethernet (wired or wireless) and PSTN/PABX.

Typical Applications

PowerStore can be integrated and controlled in a number of different ways.

Frequency and Voltage Support

In an isolated system frequency can change rapidly with changes in the output. An example is with a renewable energy generator or a swinging load.

PowerStore can be used to smooth out changes in frequency by calculating the average system frequency and then using a dead band around this average frequency to determine when it generates or consumes active power. If the actual system frequency is within the dead band, PowerStore frequency support function is inactive. If the actual system frequency falls outside of the dead band, PowerStore will respond by charging or discharging to limit the frequency deviation.

Changes to the average system frequency are allowed to occur to accommodate for operations in droop mode or due to the presence of a time correction system.

The PowerStore also supports system voltage. It uses the average system voltage in combination with a dead band, similar to the frequency support control algorithm. If the actual system voltage is outside the dead band the PowerStore generates reactive power to limit the amount of voltage deviation. Parameters for the dead band and associated control algorithm are adjustable during commissioning.

All measurements of system voltage and frequency are taken at the PowerStore's low voltage connection point. Alternatively a high voltage connection point can be used as well.

Through the above voltage and frequency support the PowerStore is able to work like a "noise filter" to suppress voltage and frequency fluctuations in the power system. PowerStore is capable of supporting frequency or voltage until it has reached its total nominal kVA power limit or exhausts stored energy. It ramps its power flow down to near zero if it approaches the fully charged or empty state.

PowerStore Charge Control

The charge level at which the PowerStore normally operates can be set between full and empty during commissioning.

The normal charge level is set to ensure there is sufficient energy to carry out the frequency support for smoothing the power system load fluctuations plus a margin to cover the loss of generation plant such as a diesel generator.

The recharging or discharging back to the idle energy level is controlled by a maximum power level that the PowerStore will consume or generate. Maximum power level can be set as a fixed parameter for charging or discharging or adjusted dynamically by an external power system management system during operation (e.g. the external power management system may only want to recharge if renewable power is available).

Step Load Response

The PowerStore has a very fast response time both for charging as well as discharging. In case of loss of plant within a power system (e.g. a generator has tripped offline) usually a step in the system load appears which results in a large frequency deviation. Such changes can cause load shedding of consumer feeders.

PowerStore is capable of compensating for this step load by discharging up to its nominal power rating within milliseconds. After PowerStore has picked up the load and discharges its energy into the power system it gradually reduces its power output to pass the load back to the power system. In this event the PowerStore acts like a "shock absorber" to dampen the step load impact on the system's frequency and voltage.

In the above case a power management system coordinating the schedule of generation plant needs to call replacement capacity to ensure the PowerStore can pass the additional load back to the generators. For this purpose the PowerStore provides a process interface that allows other controllers to monitor its status.

PowerStore working like an electrical "noise filter" to smooth power fluctuations, plus the ability to minimise the impact from loss of plant through the "shock absorber", makes PowerStore ideal for managing the starting of large loads or supporting system stability after a re-closing event.

Spinning Reserve Reduction

Isolated power systems require the provision of spinning reserve to allow for the sudden increase in load or the sudden loss of generation plant. Spinning reserve is usually provided by the conventional generators such as diesel or gas fuelled reciprocating engines. As a result generators are not operated at their rated power output where the fuel efficiency is usually the highest.

PowerStore is able to provide spinning reserve in the power system and allow the operation of the generation plant closer to its rated power output. It even allows the system load to exceed the generation capacity online for a short amount of time, delaying engine start if load changes are only of short duration.

Through the measurement of power output of each generator the PowerStore "load shares" the peak power of the generators and provides its share when the generators are exceeding their rated power. In case the charge level of the PowerStore falls below a set parameter, the supervising power management system schedules another generation plant online.



Figure 9 - Diesel Power Station Graciosa Island, Azores

Fault Ride Through

PowerStore is able to ride through faults, providing grid stability in case of a loss of a generator or large system disturbance.

The PowerStore is capable of providing real and reactive power to support the system

- When the system voltage is depressed
- During a fast rate of system frequency change
- During an instantaneous voltage phase shift

The above events usually occur during line faults within the distribution system. PowerStore has been designed to ride through those distribution faults, provide system stability and support the system recovery after the fault has been cleared.

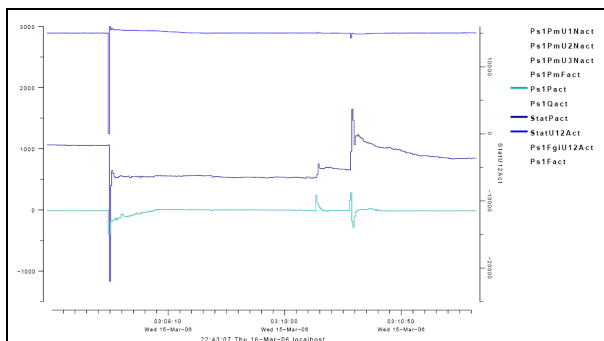


Figure 10 - PowerStore actual Fault Ride Through event recorded

Backup Power Supply

In the event of a mains failure (black station) the flywheel will slowly spin down until standstill. While it is spinning down it provides power to keep the Control and SCADA system alive to monitor the controlled shutdown process. No external UPS backup is required.

Protection

The PowerStore has a number of protection systems in place including but not limited to:

- Mains Over Voltage
- Flywheel and Converter Over Temperature
- Flywheel Over Speed
- Converter Over Current

The PowerStore automatically de-rates itself in case the converter system detects a temperature overload.

PowerStore 500

Specifications

- Design Life 20 years
- Nominal Supply Voltage 3 ph, 380 Vac - 440 Vac
- Supply Frequency 50/60Hz
- Max. Mains Voltage 480V
- Aux AC Supply.....3 ph + N, 380 Vac – 440 Vac, 50/60Hz, 50A

- Response time zero to nominal power 5msec
- Minimum operating phase-phase voltage 100V
- Fault ride through minimum phase-phase voltage 0V
- Max rate of frequency change +/- 0.1Hz/ms
- Output short circuit protectionYes
- Fault current available.....Yes¹
- Paralleling of unitsYes

Technical Data

- Nominal kVA rating (@ 415V) +/- 500kVA
- Nominal kW rating (@ 415V) +/- 500kW
- Nominal kvar rating* (@ 415V) +/- 500kvar
- Nominal Current rating 720 A

* (Power Factor from 0 leading to 0 lagging is possible)

- Flywheel Energy Stored (@ 3600rpm) 18MWsec
- Estimated Discharge/Charge Time @ 100kW 150s
- Estimated Discharge/Charge Time @ 500kW 30s
- Flywheel Operating speed range. 1800 rpm – 3600 rpm
-
- Power losses @ min operating speed 12kW
- Power losses @ max operating speed 15kW
- Power Conversion efficiency charge or discharge >90%²
- Minimum Charging Power spin-up 35 kW
- Nominal DC-link voltage..... 700 Vdc

Dimensions and Weights

Same as Standard Hi-Cube20' Shipping Container

- Dimensions (D x W x H)..... 6000 x 2400 x 2900 mm
- Weight..... 12,520 kg
- Cooling..... Refrigerative

Environmental

- Operating Temperature -5degC to +46degC
- Humidity 95% non condensing
- Wind Loading Category IV (3sec gust >65m/s)
- Sound Power Level less than 75dB(A)

Optional the container can be prepared for a severe marine environment close to seaside installations.

Communication

- Supported Protocols:
 - MODBus/TCP Slave
 - Pool Protocol (Powercorp Specific Protocol)
 - Others available on request
- Interfaces:
 - Ethernet..... Wired or Wireless
 - Telephone..... PSTN/PABX
 - Cellular Telephone..... GSM/GPRS, NextG

¹ up to the fault current limit

² excluding 12-15kW spinning and inverter losses

PowerStore 1000

Specifications

- Design Life 20 years
- Nominal Supply Voltage 3 ph, 380 Vac - 440 Vac
- Supply Frequency 50/60Hz
- Max. Mains Voltage 480V
- Aux AC Supply....3 ph + N, 380 Vac – 440 Vac, 50/60Hz, 50A

- Response time zero to nominal power 5msec
- Minimum operating phase-phase voltage 100V
- Fault ride through minimum phase-phase voltage 0V
- Max rate of frequency change +/- 0.1Hz/ms
- Output short circuit protectionYes
- Fault current available.....Yes³
- Paralleling of unitsYes

Technical Data

- Nominal kVA rating (@ 440V) +/- 1,000kVA
 - Nominal kW rating (@ 440V) +/- 1,000kW
 - Nominal kvar rating* (@ 440V) +/- 1,000kvar
 - Nominal Current rating 1,300 A
- * (Power Factor from 0 leading to 0 lagging is possible)

- Flywheel Energy Stored (@ 3600rpm) 18MWsec
- Estimated Discharge/Charge Time @ 100kW 150s
- Estimated Discharge/Charge Time @ 500kW 30s
- Estimated Discharge/Charge Time @ 1000kW 15s
-
- Flywheel Operating speed range. 1800 rpm – 3600 rpm
-
- Power losses @ min operating speed 12kW
- Power losses @ max operating speed 15kW
- Power Conversion efficiency charge or discharge >90%⁴
- Minimum Charging Power spin-up 35 kW
- Nominal DC-link voltage..... 700 Vdc

Dimensions and Weights

As per Standard Hi-Cube 40' Shipping Container

- Dimensions (D x W x H)..... 12000 x 2480 x 3330 mm
- Weight.....app. 18,000 kg
- Cooling..... Refrigerative

Environmental

- Operating Temperature -5degC to +46degC
 - Humidity 95% non condensing
 - Wind Loading Category IV (3sec gust >65m/s)
 - Sound Power Level less than 75dB(A)
- Optional the container can be prepared for a severe marine environment close to seaside installations.

Communication

- Supported Protocols:
 - MODBus/TCP Slave
 - Pool Protocol (Powercorp Specific Protocol)
 - Others available on request
- Interfaces:
 - Ethernet..... Wired or Wireless
 - Telephone..... PSTN/PABX
 - Cellular Telephone..... GSM/GPRS, CDMA/1x

³ up to the fault current limit

⁴ excluding 12-15kW spinning and inverter losses

PowerStore 1800

Specifications

- Design Life 20 years
- Nominal Supply Voltage 3 ph, 380 Vac - 440 Vac
- Supply Frequency 50/60Hz
- Max. Mains Voltage 480V
- Aux AC Supply....3 ph + N, 380 Vac – 440 Vac, 50/60Hz, 50A

- Response time zero to nominal power 5msec
- Minimum operating phase-phase voltage 100V
- Fault ride through minimum phase-phase voltage 0V
- Max rate of frequency change +/- 0.1Hz/ms
- Output short circuit protectionYes
- Fault current available.....Yes⁵
- Paralleling of unitsYes

Technical Data

- Nominal kVA rating (@ 415V) +/- 1800kVA
 - Nominal kW rating (@ 415V) +/- 1500kW
 - Nominal kvar rating* (@ 415V) +/- 1800kvar
 - Nominal Current rating 2500 A
- * (Power Factor from 0 leading to 0 lagging is possible)

- Flywheel Energy Stored (@ 3600rpm) 18MWsec
- Estimated Discharge/Charge Time @ 100kW 150s
- Estimated Discharge/Charge Time @ 500kW 30s
- Estimated Discharge/Charge Time @ 1000kW 15s
-
- Flywheel Operating speed range. 1800 rpm – 3600 rpm
-
- Power losses @ min operating speed 12kW
- Power losses @ max operating speed 15kW
- Power Conversion efficiency charge or discharge >90%⁶
- Minimum Charging Power spin-up 35 kW
- Nominal DC-link voltage..... 700 Vdc

Dimensions and Weights

As per Standard Hi-Cube 40' Shipping Container

- Dimensions (D x W x H)..... 12000 x 2480 x 3330 mm
- Weight.....app. 18,000 kg
- Cooling..... Refrigerative

Environmental

- Operating Temperature -5degC to +46degC
- Humidity 95% non condensing
- Wind Loading Category IV (3sec gust >65m/s)
- Sound Power Level less than 75dB(A)

Optional the container can be prepared for a severe marine environment close to seaside installations.

Communication

- Supported Protocols:
 - MODBus/TCP Slave
 - Pool Protocol (Powercorp Specific Protocol)
 - Others available on request
- Interfaces:
 - Ethernet..... Wired or Wireless
 - Telephone..... PSTN/PABX
 - Cellular Telephone..... GSM/GPRS, CDMA/1x

⁵ up to the fault current limit

⁶ excluding 12-15kW spinning and inverter losses