24 V nonstop – even upon power failure

The right UPS system for every application – summary of advantages and disadvantages

A reliable power supply is essential for guaranteeing the productivity of automated plants and machines. PLCs, sensors and actuators are usually provided with 24 V DC from a switched-mode power supply. Modern power supply units such as SITOP offer a maximum degree of security for the supply. However, they are not invulnerable to longer power supply failures. Critical applications therefore require upgrading to an uninterruptible power supply. But which UPS system is the right one, and what must be considered when dimensioning?

AC or DC UPS?

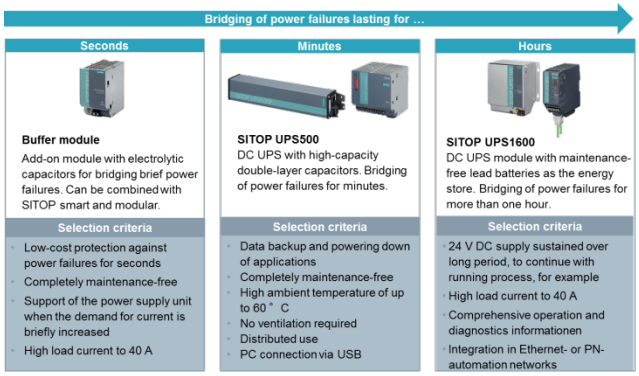
In order to provide protection against power failure, an uninterruptible power supply can be used on the AC or DC side. The advantage of an AC UPS is that it provides buffering of all electrical consumers, e.g. also of AC drives. However, an AC UPS is more expensive than a DC UPS. If it is permissible with the application to only buffer the 24 V side in the event of a power failure, a DC UPS is quite definitely the more economical solution. On the one hand, the powers required are usually smaller, resulting in smaller dimensioning of the DC UPS, and on the other hand an AC UPS is always more expensive because of its increasingly complex design.
Furthermore, the total efficiency is significantly better with a DC UPS. This is because conversion of the battery voltage into an AC voltage and the repeated transformation into the required 24 V DC voltage are unnecessary.

With the DC UPS, the energy is provided where it is required, namely directly on the consumer without "loss-making detours".

Figure 1: With this control cabinet for controlling a crane system, an AC UPS which had to be mounted on top of the cabinet because of its size (photo left) was replaced by three DC UPS modules. Since the more compact SITOP PSU300M 24 V/ 20 A generation of power supplies was used at the same time, all three power supplies even fitted together with the three SITOP UPS500S 15A/5 kW modules on the same DIN rail.

The right solution for every application

No other manufacturer of power supplies provides such a comprehensive range of units for safeguarding a 24 V DC supply like Siemens does. The range extends from a simple buffer module up to the multi-function DC UPS. Three different solutions can be used depending on the requirements:



Bridging brief power failures

When power supply conditions are unstable, for example in low-meshed network infrastructures, brief power failures may occur occasionally or even frequently as a result load transfers in the network, for example. Problems following such interruptions with non-buffered power supplies are the long ramp-up times and initialization of the automation system or involved drives. It is already possible to significantly increase the plant availability by using a buffer module for bridging such brief interruptions of up to 10 seconds. The buffer module is simply connected in parallel with the SITOP smart or SITOP modular power supply. The electrolytic capacitors supply up to 40 A which supports the power supply even in the event of an overload.

Protection of plant status upon power failure

In applications where a plant is to be switched off in the event of a power failure with retention of the last plant status, extended bridging of the power failure is required. Such requirements are typical for PC-based automation, visualization, or archiving of operating data. Recording of the failure, saving of the plant status, as well as controlled shutdown of the PC require bridging in the minute range. Comparatively high buffer reserves are required in such a scenario by powerful industrial PCs, especially when a large panel has to continue to operate during the shutdown. High buffer capacities are also required by actuators which have to be driven into an end position or processes in which plant components must continued to be powered until the power supply is restored. This is the case, for example, when measured data is being recorded or a communications link must be maintained. Uninterruptible power supplies (UPS) are required in such situations.

SITOP power supplies with 24 V output voltage can be upgraded into a fully-fledged UPS. Two different UPS concepts are available corresponding to the mentioned requirements. They mainly differ in the type of energy store. One of them is based on lead-acid batteries, the other on double-layer capacitors. All DC UPS modules have the same basic functionality with comprehensive monitoring functions and signaling contacts, and are available with a USB interface. The battery-based SITOP UPS1600 is also available with an Industrial Ethernet/PROFINET interface.

Free software tools provide simple integration into PC-based automation solutions. They support further processing of status messages, safe shutdown, and correct restarting of the system. The UPS1600 with IE/PN interface can be configured via the TIA Portal or integrated in TIA (Totally Integrated Automation) with STEP 7 and WinCC.

The energy storage makes the difference

Whether the capacitor-based or the battery-based concept is right for the respective application depends on the respective demands. If long buffer times are required, the UPS with lead-acid batteries is the best choice. They can supply energy for hours depending on the current requirements. Battery modules for the UPS1600 are available with capacities ranging from 1.2 Ah to 12 Ah. Connection in parallel allows for a flexible combination for the required capacity. A UPS1100 battery module is equipped with electronics with specific parameters as well as for recording the current operating data that are read by the UPS1600 UPS module via a two-wire cable (Energy Storage Link).
The UPS modules are available with rated output currents of 10 A, 20 A and 40 A. They also offer high overload capability and can supply three times the rated current for 30 ms and 1.5 times the rated current for 5 s per minute.

In many cases, a plant can be brought into a safe status within minutes, and thus minimize the effects of a power failure. Many advantages for such time requirements are provided by the SITOP UPS500 based on double-layer capacitors. These are also referred to as ultracaps, supercaps or super capacitors because of their high energy density. The innovative UPS for installation in control cabinets consists of a basic unit with energy storage of 2.5 or 5 kW, and delivers an output current of up to 15 A. Add-on modules of 5 kW each permit configurations with up to 20 kW.

Versions with IP65 protection for use outside the control cabinet, provide an output current of 7 A and are available with energy storage of 5 or 10 kW.

The type of energy storage is not only critical for the buffer time, is also decisive for the possible applications of the two types of SITOP UPS systems.

Available capacity of lead batteries is highly dependent on the temperature

Lead batteries are extremely temperature-sensitive, since the charging and discharging processes of a battery are the result of an electrochemical reaction. Aging depends on the electrolyte used (sulfuric acid) and the plates serving as poles (lead and lead oxide), and is highly temperature-dependent. Temperatures higher by 10 K reduce the service life by half. With an ambient temperature of 40 °C, for example, the service life is therefore only 1/4 of that at the rated operating temperature of 20 °C. A lead battery with a service life of 4 years at the rated conditions must therefore be replaced after only one year when used at 40 °C.
Special batteries with an increased thermal stability can also be used as an alternative to conventional lead batteries, but these are also more expensive. SITOP offers, for example, a high-temperature battery with pure lead plates for use at temperatures from -40 to +60 °C.

Battery modules SITOP UPS1100	Maintenance-free lead-acid batteries 24V/ 1.2 Ah, 3.2 Ah, 7 Ah, 12 Ah	Maintenance-free pure lead-acid battery (high temperature battery) 24 V/ 2.5 Ah
Service life (when capacity falls to 50% of original capacity) depending un the battery temperature	Approx. 4 years at +20 °C Approx. 2 years at +30 °C Approx. 1 year at +40 °C	Approx. > 10 years at +20 °C Approx. 7 years at +30 °C Approx. 3 years at +40 °C Approx. 1.5 years at +50 °C Approx. 1 year at +60 °C
Ambient temperature range	0... +40 °C	-40...+60 °C

Table 1: Service life and ambient temperature range of SITOP UPS1100 battery modules

How supercaps work and the advantages they offer

A chemical reaction does not take place in double-layer capacitors. They store the charge in an electrochemical double layer (the so-called Helmholtz layer), where positive and negative ions of the electrolyte move through the electric field to the corresponding electrode. They are therefore more resistant to aging than lead batteries, with regard to both the charging cycles and the temperature. In the SITOP UPS500, the supercaps only lose approx. 20% of their capacity after eight years of operation
and an ambient temperature of 50 °C. The UPS is therefore fully maintenance-free, and replacement of the energy storage is unnecessary.
Even at an ambient temperature of 40 °C, the capacitor UPS is amortized in the second year of operation. The slightly higher cost is compensated by the second battery replacement for a conventional UPS.
Even more costs can be saved with regard to the control cabinet installation. Compared to lead batteries, the capacitors do not emit hydrogen and there is therefore no need to ventilate the control cabinet.

An additional advantage provided by the innovative energy storage is the short charging time of a few minutes (see table 2 "Buffering and charging times SITOP UPS500"). This guarantees fast supply readiness following a power failure and also results in a high availability.

How is a DC UPS system configured?

The criteria for configuration of the UPS are the buffer time, the operating current, the peak current and the ambient temperature. The example below shows the configuration of a DC UPS, which is designed to protect an automation application with a 24 V industrial PC from a power failure. The backup is intended for a Panel PC that is to save data and shut down normally in the event of a power failure. To retain or save the measured values, the sensors should also be supplied with 24 V via the DC UPS. To lower the load on the DC UPS, the actuators are not to be buffered and are connected directly to the 24 V output of the power supply.

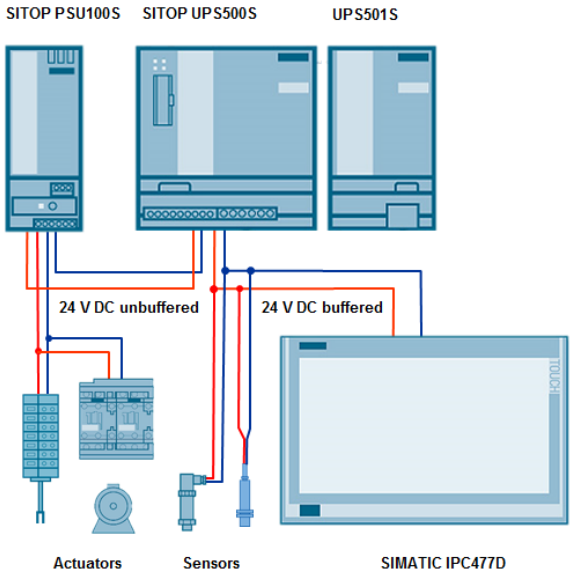


Figure 2: Application example for configuration of an uninterruptible 24 V power supply

Application conditions:
Time required to save and shut down the system: 55 s,
ambient temperature: 40 °C,
actuators are not buffered.

1) Calculation of current requirements and selection of power supply

a) Calculation of max. operating current requirement:
Buffered 24 V feeder: 2.7 A (PC 477D) + 1 A (sensors) + 2 A (UPS500S charging current, can be set to 1 or 2 A) = 5.7 A
Non-buffered 24 V feeder: 3 A (actuators)
Total operating current requirement: 5.7 A + 3 A = 8.7 A

b) Calculation of peak current requirement:
Buffered 24 V feeder: 6.5 A (PC 477D for 25ms) + 2 A (sensors) + 2 A (charging current) = 10.5 A
Non-buffered 24 V feeder: Actuators: 4 A (starting torque)
Total peak current requirement: 10.5 A + 4 A = 14.5 A

c) Selection of power supply for 8.7 A operating current and 14.5 A peak current requirement
=> SITOP smart 10 A (max. 15 A for 5 s)

2) Calculation of UPS output current, energy storage and selection of DC UPS

a) UPS output current at peak current requirement:
6.5 A (PC 477D for 25 ms) + 2 A (sensors) = 8.5 A

b) UPS output current for buffer mode:
2.7 A (PC 477D) + 1 A (sensors) = 3.7 A

c) Energy requirement + 25% due to 20% loss in capacity after
approx. 8 years: 3.7 A x 24 V x 55 s x 1.25 = 6105 W
Check in table for UPS500 "Buffering and charging times":
Buffering time with 4 A operating current and 7.5 kW: 61 sec = OK!

d) Selection of DC UPS for 8.5 A peak output current and 6.105 kW
=> SITOP UPS500S 15A/ 2.5 kW and add-on module SITOP UPS501S 5 kW (total 15A/ 7.5 kW)

	SITOP UPS500S/501S configurations				
Basic unit	2.5 kWs	5 kWs	2.5 kWs	5 kWs	2.5 kWs
Expansion modules	–	–	1 x 5 kWs	1 x 5 kWs	2 x 5 kWs
Total energy	2.5 kWs	5 kWs	7.5 kWs	10 kWs	12.5 kWs
Buffering times					
Load current					
0.5 A	134 sec	236 sec	390 sec	478 sec	632 sec
0.8 A	90 sec	167 sec	266 sec	346 sec	440 sec
1 A	75 sec	138 sec	219 sec	296 sec	365 sec
2 A	38 sec	76 sec	122 sec	156 sec	203 sec
3 A	26 sec	52 sec	82 sec	106 sec	136 sec
4 A	19 sec	39 sec	61 sec	81 sec	101 sec
5 A	15 sec	31 sec	49 sec	65 sec	81 sec
6 A	12 sec	26 sec	40 sec	55 sec	67 sec
7 A	10 sec	21 sec	34 sec	47 sec	58 sec
8 A	8 sec	18 sec	29 sec	40 sec	50 sec
10 A	6 sec	15 sec	23 sec	32 sec	39 sec
12 A	4 sec	12 sec	19 sec	26 sec	32 sec
15 A	3 sec	9 sec	14 sec	20 sec	25 sec
Charging times					
Charging current					
2 A	54 sec	120 sec	158 sec	223 sec	263 sec
1 A	110 sec	205 sec	311 sec	425 sec	503 sec

Specifications at rated input voltage and ambient temperature +25°C (unless otherwise specified)

Table 2: Check in the table Buffering and charging times SITOP UPS500

SITOP Selection Tool – convenient selection guide for power supply and DC UPS

The selection with the SITOP Selection Tool is more convenient and detailed than the manual selection, especially for the more demanding dimensioning of a DC UPS with batteries. The selection guide offers the possible DC UPS solutions with a few mouse clicks, depending on the requirements, with capacitors or batteries.
In addition to the criteria operating current, peak current and buffer time, you can also specify the ambient temperature and the minimum buffer voltage. The minimum buffer voltage is the lowest input voltage at the load at which its function is still guaranteed. It influences the dimensioning of a DC UPS with battery. This is because if the battery voltage drops more, a longer buffer time is possible with the same battery capacity. The ambient temperature plays a crucial role for the service life of a battery, as described on page before.
With the additional criteria, the SITOP Selection Tool can assess the actual conditions even better when it determines the battery capacity. This process would be rather time-consuming if done manually.
The matching power supply can be selected just as conveniently from the vast range of SITOP products. The tool compiles all required CAD data, circuit diagram macros and appropriate documentation for the selected power supply and the DC UPS to enable quick configuration.

www.siemens.com/sitop-selection-tool

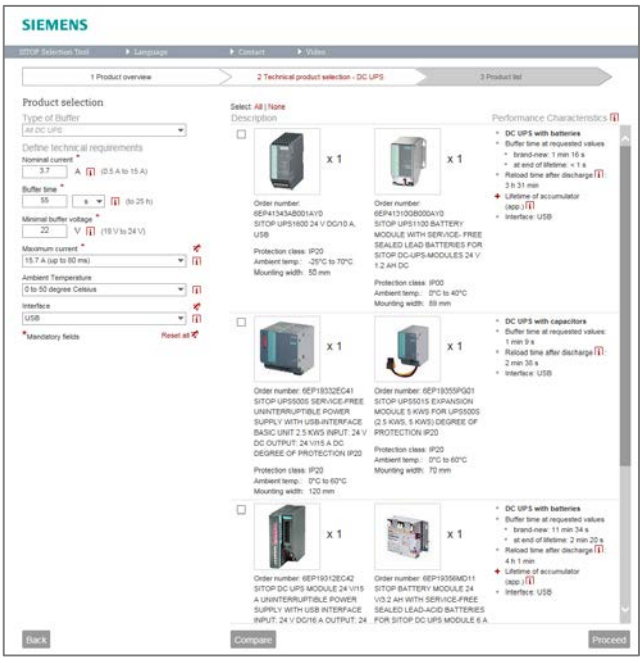


Figure 3: After entering a few criteria, the SITOP Selection Tool offers a selection of suitable DC UPS configurations.

How is the DC UPS integrated into the plant?

The automation system must be informed about the status of the DC UPS so that it can respond correctly to the situation. Communication takes place via digital outputs, USB or Ethernet/PROFINET interfaces.

DC UPS	Communication	Controller	Engineering tool
SITOP UPS500 (with ultracaps)	Digital outputs	PLC	-
	USB	PC	DC UPS Tool
SITOP UPS1600 (with battery modules)	Digital outputs	PLC	-
	USB	PC	SITOP UPS Manager
	Industr. Ethernet/ Profinet	PC	
		PLC	STEP 7, TIA Portal

Table 3: A free engineering tool is available for the DC UPS with interface and controller type that must be buffered; it can be used for easy configuration of the DC UPS and visualization of the operating state.

Digital outputs

The most important status messages are displayed by LEDs for all SITOP DC UPS modules and output via signaling contacts. The signals are evaluated by digital inputs at the controller. Signaling and terminal assignment are identical for the DC UPS modules SITOP UPS500S and SITOP UPS1600 (see Table 4), which means engineering and wiring of both UPS systems is almost the same.

SITOP UPS1600 and SITOP UPS500S			
Relay contact	Terminal/description		Signal
Relay 1	1	Bat.	Buffer operation or DC UPS off
	2		
	3	o.k.	Normal operation (mains operation)
Relay 2	4	Alarm	in normal operation: Not ready for buffering in buffer operation: Alarm, near switching off
	5		Cycle0,25 Hz : Defective energy store or buffering of the selected buffer time is not possible
	6	Ready to Buffer	Buffer operation possible
Relay 3	7	Bat. > 85%	Energized state: Energy store be charged more than 85%, buffering of the selected buffer time is not possible
	8		

Table 4: The digital outputs of all SITOP DC UPS modules are the uniform in accordance to this terminal assignment.

The use of relay contacts is ideally suited for basic automation applications without networking, such as obstruction lighting, hydroelectric plants or thermal power stations. For these insular applications, the UPS1600 is especially equipped with the "Start from Battery" function. When a plant is started without line voltage, the 24 V loads are supplied by the battery.

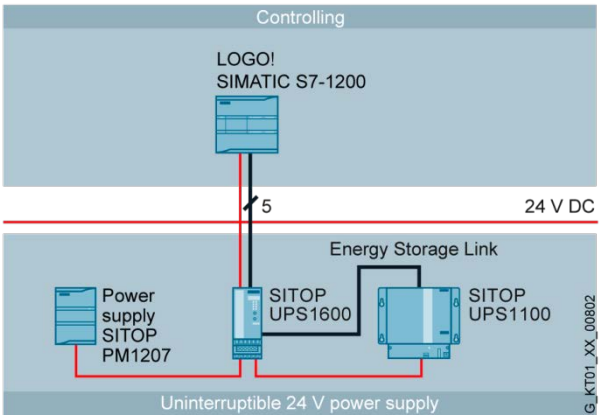


Figure 4: Backing up simple automation applications with status signaling via digital outputs.

The UPS settings are made on the front of the device. Among other things, you can set the voltage connection threshold, the buffer time and the operating current with DIP switches or rotary switches. For the coded UPS1100 battery modules, the operating current is pre-defined, depending on the temperature, via the 2-wire cable "Energy Storage Link" and therefore need not be set.

Interfaces for PC-based or PLC-based systems

For communication with PCs or PLCs, the SITOP DC UPS modules come equipped with an optional USB port or two Ethernet interfaces. Free engineering tools, which should be used according to Table 3, assist in the integration of the DC UPS into the plant.

SITOP UPS500 with USB port on the PC

UPS modules with USB port are best suited for applications with an automation computer and without further networking. The UPS500 responds via USB port to the same status messages that are also output via the contacts (see Table 4). The UPS 500 can be easily configured with the DC UPS Tool, which means it can be used to start applications at specific events, such as an emergency program in case of a power failure or buffer mode. The DC UPS Tool visualizes the operating status of the DC UPS in a window. The information can also be further processed using the integrated OPC server.

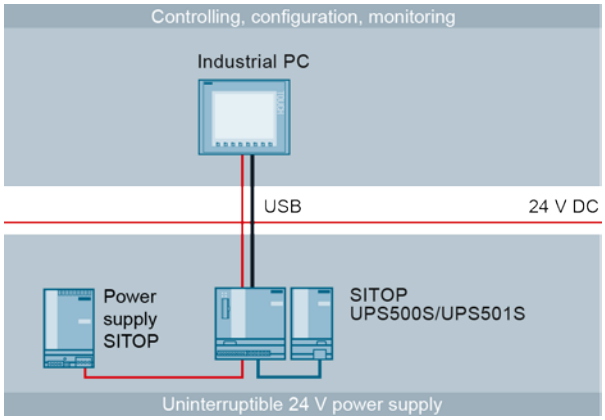


Figure 5: Backing up a 24 V automation computer with communication via USB

The "Reset after Buffering" function is available for the versions with USB as well as Industrial Ethernet. Without this function, the computer remains switched off during shutdown when the power and therefore the 24 V supply returns. With this function, the 24 V supply is interrupted for 5 seconds after shutdown (interface is not supplied with voltage) which makes the computer start up automatically again.

A general disadvantage of communication via USB is the restriction to a cable length of about 5 meters if no additional measures for signal amplification are taken.

SITOP UPS1600 with USB port or Industrial Ethernet interface on PC

If the UPS1600 backs up PC-based controllers, communication can take place via USB or Industrial Ethernet (IE). Communication via the two 2 IE ports has the great advantage that the UPS can be easily integrated into any LAN infrastructure and multiple PCs can be shut down according to the master-slave principle if a power failure occurs.

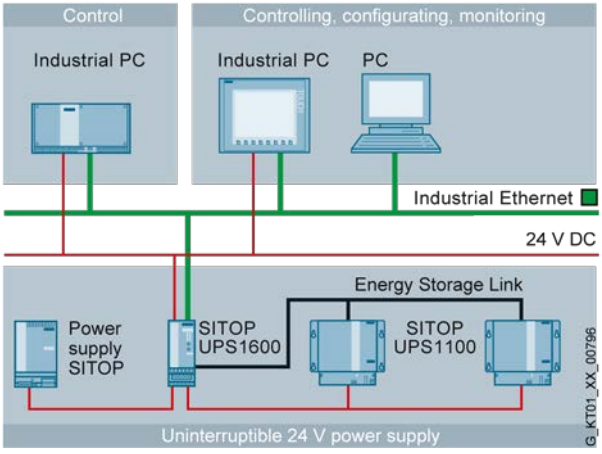


Figure 6: Backing up multiple 24 V PCs. Communication via Industrial Ethernet supports comprehensive diagnostics and targeted shutdown in the master-slave module in case of power failure

The events to which the UPS1600 can respond are identical for USB port and Industrial Ethernet interface. When compared to signaling via contacts, you can also evaluate the remaining buffer time and the status of the battery charge via these ports. This means a more timely response to critical states is possible. Parameters can be conveniently assigned via the SITOP UPS Manager. It offers additional visualization compared to the DC UPS Tool (for UPS500 and the predecessor DC UPS 6EP1931...):

- Monitoring of pending alarms and alarm history
- Operating data: Device data and device parameters
- Trend charts over time:
  Operating current, input voltage, remaining buffer time, battery temperature, battery charge, charging current

Figure 7: The various trend charts of the SITOP UPS Manager support comprehensive diagnostics of the network status and the status of the DC UPS.

Remote visualization of the operating state and the parameters is also possible via the integrated web server. The device status along with the network connection can be easily monitored in the SINEMA Server network management software.

SITOP UPS1600 with PROFINET at controller

For backing up SIMATIC controllers, the PROFINET connection and the TIA Portal offer optimal options for easy and complete system integration. Function blocks for the SIMATIC S7-300, 400, 1200 and 1500 enable processing of all UPS1600 operating data and therefore response to each state of the DC UPS. The state of the DC UPS can evaluated in detail especially when using the coded battery modules UPS1100. Up to six UPS1100 battery modules can be connected in parallel and evaluated individually.

Here is a selection of the UPS data that can be evaluated:

- Input voltage and input current
- Output voltage and output current
- Charging voltage and charging current
- Temperature UPS1600 and UPS1100 battery modules
- Capacity of the battery in total and individually
- Remaining buffer time
- Number of battery modules
- Recommended battery replacement

In addition, all device parameters can be read, for example, end-of-charge voltage, rated capacity, permissible temperature range, article number, serial number and version number.

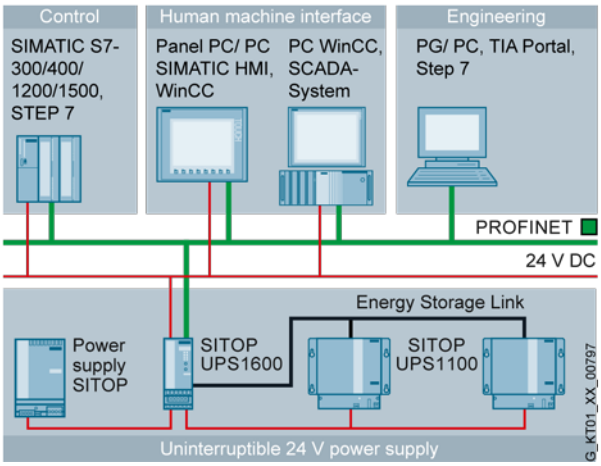


Figure 8: Backing up an automation solution with PLC networked via PROFINET. Even multiple controllers can be brought to a defined state independent of each other

The operating status of the DC UPS can be easily visualized using ready-to-use faceplates. Faceplates for SIMATIC Panels and WinCC make for easier diagnostics in the area of production automation.

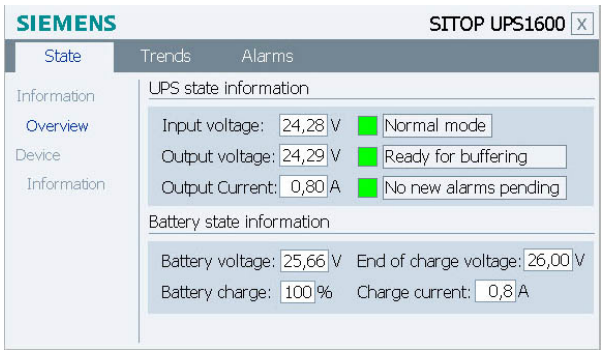


Figure 9: Faceplates for WinCC help visualize comprehensive diagnostics including trend charts and alarm messages

Download:
SITOP UPS1600: Faceplates and STEP 7 communication blocks

SITOP UPS with PROFINET on process control systems

A free UPS1600 library with software blocks and faceplates is also available for the SIMATIC PCS 7 process control system. Automatic information about operating status messages such as power failure (buffer mode) or maintenance demanded as well as preventive battery replacement increase availability of the plant in process automation even more.

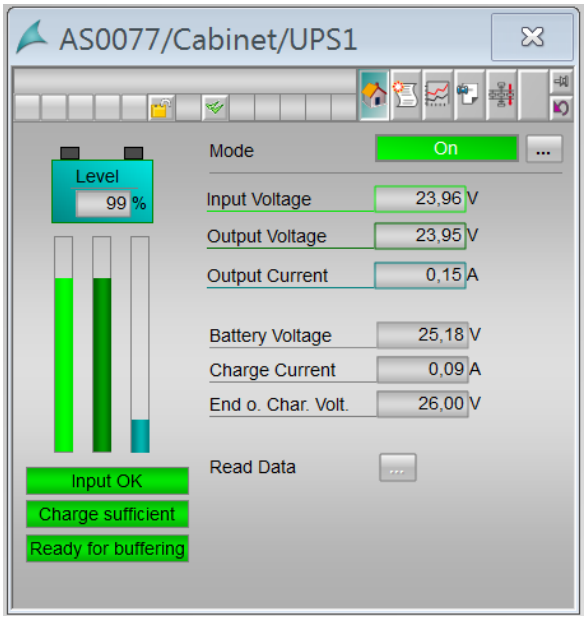


Figure 10: Faceplates for the SIMATIC PCS 7 enable easy diagnostics and maintenance of the DC UPS in the process industry

Download:
SITOP UPS1600 library for integration in SIMATIC PCS 7 V8.0 + SP2 and SIMATIC PCS 7 V8.1

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