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".

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.

24 V nonstop – even upon power failure

The matching 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:

Buffer module

Add-on module with electrolytic capacitors for bridging brief power failures. Can be combined with SITOP modular.

Selection criteria:

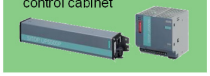
- Low-cost protection against power failures of up to 10 seconds maximum
- Support of the power supply unit when the demand for current is briefly increased
- High load current up to 40 A

SITOP UPS500

DC UPS with high-capacity double-layer capacitors. Bridging of power failures for minutes.

Selection criteria:

- Data backup and powering down of applications in the minute range
- Completely maintenance-free
- High ambient temperatures of up to 60°C
- No ventilation required because no gas is emitted
- Distributed use without control cabinet



SITOP DC UPS

DC UPS module with maintenance-free lead-acid batteries as the energy store. Bridging of power failures for more than one hour.

Selection criteria:

- 24 V supply sustained over long period, to continue with running process, for example.
- High load current to 40 A

Bridging of brief power failures

In the case of unstable power supply conditions, e.g. in low-meshed network infrastructures, brief power failures may occur occasionally or even frequently as a result of e.g. load transfers in the network. Problems following such interruptions with non-buffered power supplies are the long run-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 modular power supply. The electrolytic capacitors deliver 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 powering down of the PC require bridging in the minute range. Comparatively high buffer reserves are required in such a scenario by e.g. powerful industrial PCs, especially when a large panel has to run further when powering down. High buffer capacities are also required by actuators which have to be driven into an end position or processes in which plant components have to be powered further until the power supply is restored, for example to record measured data or to retain a communications link.

Uninterruptible power supplies (UPS) are required in such cases.

SITOP provides add-on modules with which a power supply unit can be upgraded into a fully-fledged UPS. Two different UPS concepts are available corresponding to the mentioned requirements. They 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 PC interface.

A free software tool provides simple integration into PC-based automation solutions. It supports further processing of status messages, safe powering down, and correct restarting of the system.

The energy store makes the difference

Which UPS concept is right for the respective application thus depends on the respective demands. If long buffer times are required, the UPS with lead-acid batteries is the best choice. For these can deliver energy for hours depending on the current requirements. SITOP battery modules with capacities ranging from 1.2 Ah to 12 Ah and which can also be connected in parallel allow flexible combination for the required capacity. The associated UPS modules are available with rated output currents of 6 A, 15 A and 40 A, thus enabling a large current requirement range to be covered.

In many cases, a plant can already be brought into a safe status within minutes, thus keeping the effects of a power failure low. Many advantages for such time requirements are provided by the SITOP UPS500 on the basis of double-layer capacitors, and these are also referred to as ultracaps or supercaps because of their high energy density. The innovative UPS for installation in control cabinets consists of a basic unit with an energy store 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, e.g. on support arms, provide an output current of 7 A and are available with an energy store of 5 or 10 kW.

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

Lead batteries under heat stress

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. A temperature higher by 10 K reduces 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 which has a service life of 4 years at the rated conditions must therefore already be replaced after 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	Maintenance-free lead-acid batteries 24V/ 1.2 Ah, 3.2 Ah, 7 Ah, 12 Ah	Maintenance-free pure lead-acid 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

Service life and ambient temperature range of SITOP battery modules

Principle of operation of supercaps and their advantages

A chemical reaction does not take place in double-layer capacitors. These 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 even after eight years of operation and an ambient temperature of 50 °C. Thus the UPS is absolutely maintenance-free, and replacement of the energy store is unnecessary.
Even at an ambient temperature of 40 °C, the capacitor UPS is amortized in the second year of operation, for the slightly higher cost is already compensated by the second battery replacement for a conventional UPS.

Costs can be saved further with regard to the control cabinet installation: compared to lead batteries, the capacitors do not emit hydrogen and it is therefore unnecessary to ventilate the control cabinet.

An additional advantage provided by the innovative energy store is the short charging time of a few minutes (see table on right). This guarantees fast readiness for buffering following a power failure and also results in a high availability.

How is a DC UPS system configured?

In many automation applications, an industrial PC is protected against power failure by a DC UPS.
Example: power supply to a SIMATIC Panel PC 477C with 19" display, sensors, and actuators.

Application conditions:
Time required to save and shut down the system: 55 s, ambient temperature: 40 °C,
actuators are non-critical 24 V consumers in event of power failure and need not be buffered

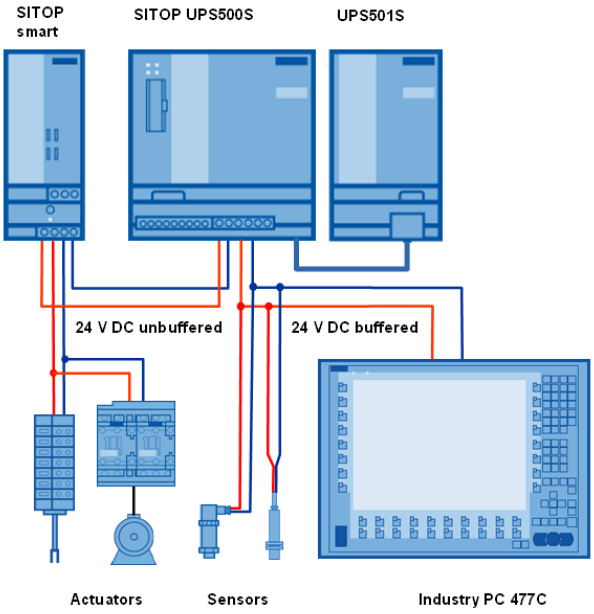
1) **Calculation of current requirements, and selection of power supply**
   a) Calculation of max. operating current requirement:
   Buffered 24 V feeder: 2.8 A (PC 477C) + 1 A (sensors) + 2 A (UPS500S charging current, can be set to 1 or 2 A) = 5.8 A
   Non-buffered 24 V feeder: 3 A (actuators)
   Total operating current requirement: 5.8 A + 3 A = 8.8 A
   b) Calculation of peak current requirement:
   Buffered 24 V feeder: 4.5 A (PC 477C for 25 ms) + 2 A (sensors) + 2 A (charging current) = 8.5 A
   Non-buffered 24 V feeder: actuators: 6 A (starting torque)
   Total peak current requirement: 8.5 A + 6 A = 14.5 A
   c) Selection of power supply for 8.8 A operating current requirement and 14.5 A peak current requirement
   => SITOP smart 10 A (max. 15 A for 5 s)

2) **Calculation of UPS output current, energy store, and selection of DC UPS**
   a) UPS output current at peak current requirement:
   4.5 A (PC 477C for 25 ms) + 2 A (sensors) = 6.5 A
   b) UPS output current for buffer mode:
   2.8 A (PC 477C) + 1 A (sensors) = 3.8 A
   c) Energy requirement + 25% due to 20% loss in capacity after approx. 8 years: 3.8A x 24V x 55s x 1.25 = 6270 W
   Check in table for UPS500 "Buffering and charging times":
   Buffering time with 4 A load current and 7.5 kW: 61 s = OK!
   d) Selection of DC UPS according to 6.5 A peak output current and 6.27 kW
   => SITOP UPS500S 15 A / 2.5 kW and add-on module SITOP UPS501S 5 kW (total 15 A / 7.5 kW)

Checking in the table "SITOP UPS500 buffering and charging times":

	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)



Application example: to offload the DC UPS, the actuators are connected to the 24 V output of the power supply. To retain or save the measured values, the sensors are powered with 24 V via the DC UPS. And of course the PC as well. The DC UPS is dimensioned such that the PC can save the data in the event of a power failure and also correctly shut down the system.

If the required buffering time cannot be achieved with the maintenance-free SITOP UPS500, the DC UPS with battery modules is the right choice. A selection table for the lead battery is also included in Catalog KT10.1 and in the corresponding brochures. However, the larger temperature sensitivity should be taken into account when dimensioning, and therefore exact determination of the battery capacity is more difficult than with the capacitor solution. Our local partners will be pleased to help you in determining the correct configuration.

However, one can always speak of two possible selection criteria. The first one is e.g. selection of twice the battery capacity in order to double the service life. Nevertheless, it is more recommendable to replace the battery at half of the expected service life since a cheaper battery with a smaller capacity can then be used, which also require less space. Furthermore, the bridging time to be configured can be observed far more reliably.

Siemens AG
Industry Sector
Industry Automation
P.O. Box 48 48
90327 NUREMBERG
GERMANY

www.siemens.com/sitop