Application Guideline • 09/2016

SIMATIC IPC – Protection against power failures

SIMATIC IPC / SITOP USV / SITOP PSU

https://support.industry.siemens.com/cs/ww/en/view/109739384

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Table of Contents

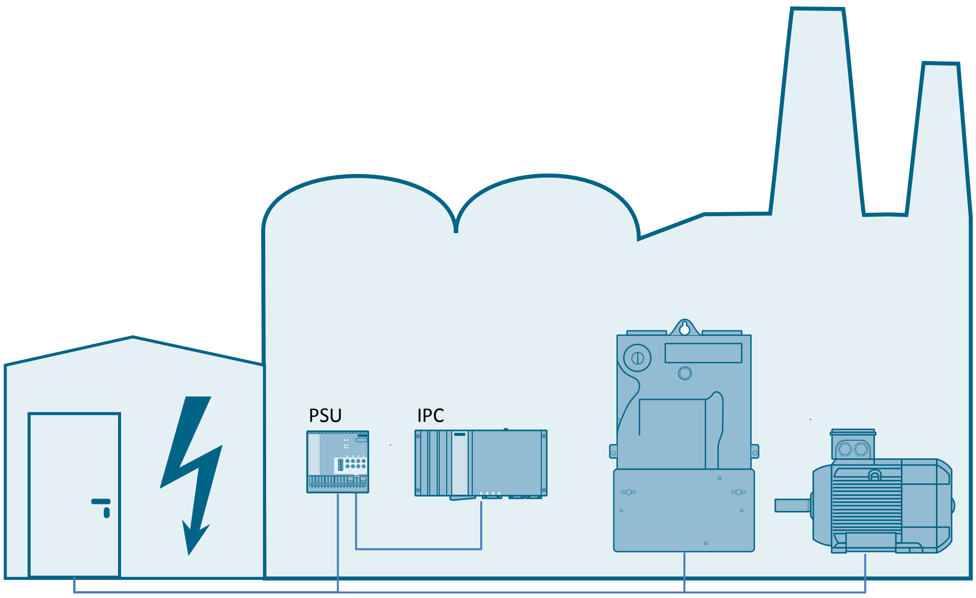
1 Task

In a production hall, there is a production machine, an electric drive motor and an industrial PC (IPC). The IPC controls and monitors the production process. The three components are fed by the same power grid.

During the switch-on process, the motor requires a high start-up current. This may cause voltage fluctuations in the electric supply grid and an insufficient power supply of the IPC. As a result, malfunctions and data loss may occur.

Therefore, the IPC shall be supplied with power from a suitable and stable power source. The IPC shall continue to work, even during a power failure of several seconds. If the power failure lasts even longer, the IPC shall shut down by itself.

Figure 1-1: Overview of the automation problem



PSU = Power Supply Unit
IPC = Industrial PC

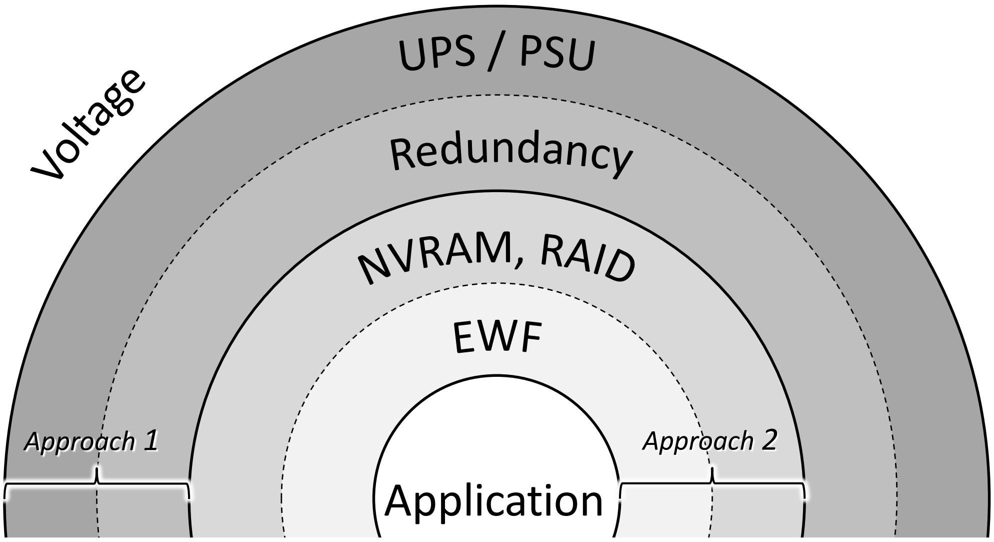
2 Solution

2.1 Solution overview

To solve the task, two different approaches are considered. On the one hand, appropriate measures shall be taken to stabilize the power supply of the IPC and to improve failure safety. On the other hand, data loss shall be prevented in the event of an inevitable power failure.

Figure 2-1 schematically shows both approaches.

Figure 2-1: Measures to compensate voltage fluctuations / failures



Approach 1: Stabilizing the power supply

There are several types of power supplies that enable a stable energy supply of the IPC. These especially include the following types of power supplies:

- Uninterrupted power supplies (UPS)
- Power supply units (PSU) with energy storage

With an energy storage, the devices are able to compensate voltage fluctuations and short interruptions in the supply grid.

Approach 2: Preventing data loss during a voltage failure

Non-volatile RAM (NVRAM) contains the data that has been stored on it prior to the power failure. Process data of a software control, for example, can be stored in the NVRAM and therefore survive a voltage failure.

If RAID controllers are used in the IPC, all data needs to be written to those RAID data carriers that are still in the RAID controller cache.

For certain application scenarios, an Enhanced Write Filter (EWF) can be activated. It prevents data changes on a data carrier.

Application

The described measures aim to increase the availability of the application. The measures are described in detail in chapter 2.2 or 2.3. Examples on how to implement these measures are described in chapter 2.4.

2.2 Stabilizing the power supply

An undisturbed operation of an IPC requires a stable power supply. This can be achieved with an UPS or a PSU.

An UPS stores electric energy in batteries and delivers it in case of a power failure or fluctuations of the input voltage. A PSU stores the electric energy in capacitors. As soon as the primary power supply has been re-established, it supplies the IPC and, at the same time, recharges the capacitors or batteries.

2.2.1 Types of power supply

SIMATIC IPCs with connection to a 230 V power grid contain an integrated industrial power supply. The industrial power supply is able to pass a broad input voltage range and compensate short voltage fluctuations. All SIMATIC IPCs have an integrated industrial power supply (according to NAMUR up to 20ms) for a safe voltage supply that is protected against grid disturbances.

A distinction is made between direct current (DC) and alternate current (AC).

- DC power supply
- AC power supply

If an IPC is operated with 24 V direct current, a separate DC power supply is frequently used.

SITOP power supplies contain buffer capacitors and are able to bridge power failures within a range of several milliseconds. Longer power failures can be compensated with additional capacitors in the PSU. Depending on the load, they can supply electric energy for several minutes.

If power failures of several minutes up to several hours need to be bridged, an UPS with batteries can be used in addition to the PSU. They supply the required energy over a longer period of time. Additional batteries expand the capacity of a UPS.

Note Further information on “24 Volt SITOP power supplies” can be found on the SITOP website \7\.

An IPC requires a certain type of power for the operation. This power needs to be supplied by the power supply (PSU) or the UPS.

Caution If the IPC is operated at full load, it consumes a lot of power. With an undersized power supply, too little power is made available to the capacitors or batteries to recharge.

The energy supply must be dimensioned such that the capacitors or batteries are supplied with sufficient loading current, even during a full-load operation.

2.2.2 Types of energy storage

To store electric energy, several energy storage types are available. At the time of the creation of this guideline, UPSes and PSUs use the following energy storage systems for IPCs:

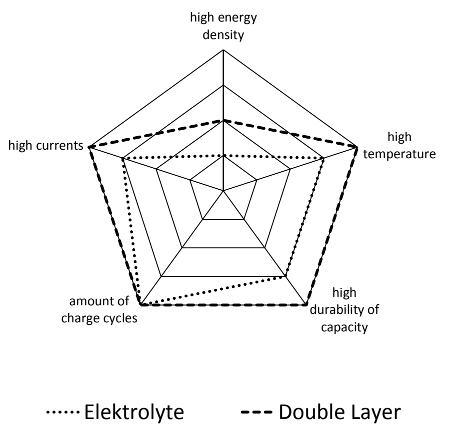
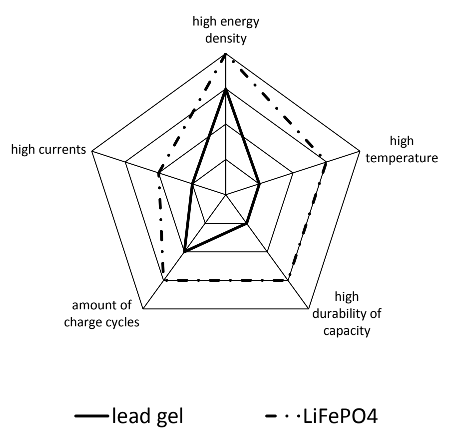
- Electrically-based capacitors
- Electrochemically-based batteries

They differ in terms of their storable amount of energy as well as in durability and in their characteristic electric properties.

Table 2-1 shows selected characteristics of energy storage systems.

- The energy density of the energy storage.
- The temperature resistance of the energy storage.
- Maintaining the capacity over a longer period of time.
- The amount of possible charge cycles of the energy storage.
- The possible currents during the charge and discharge of the energy storage.

Table 2-1: Comparison of different energy storage devices

Capacitors	Batteries
	

Amount of charge cycles

Capacitors can be repeatedly discharged and recharged without any problems. Batteries, on the other hand, may be damaged by deep discharging. Therefore, batteries are discharged and charged via a separate charge management.

High currents

Energy storage systems that are based on capacitors can quickly absorb and fully release electrical energy.

High energy density

In contrast, batteries based on lead gel, lithium iron phosphate ($LiFePO_4$) or other electrochemical energy storages can store higher quantities of electrical energy per volume. Thus, they are able to release energy over a longer period of time.

High Temperature

Temperature also affects the capacity of the energy storage. Capacitors are usually less sensitive towards high temperatures than batteries.

High durability of capacity

Over the years, the capacity of a battery decreases. Frequent charge cycles and high temperatures increase this aging effect. This may lead to existing capacities no longer being sufficient to reliably supply the IPC with power during a power failure.

There are two alternative methods to counter this effect.

- Acquiring an energy storage with a higher capacity than originally required.
- A regular inspection of the existing capacity and an early exchange of the energy storage.

The better method must be determined case by case.

Note The SITOP Selection Tool \6\ supports the user in selecting the appropriate power supply.

2.2.3 Comparison of the capacity specifications kWs and Ah

The capacity of the energy storage and the power consumption of the consumer determine the time that can be bridged during a power failure. The larger the capacity, the longer the power supply can be maintained.

The capacity of capacitors is usually specified in kilowatt seconds (kWs). For batteries, in contrast, the amount of electricity is specified in ampere hours (Ah). The following example calculation shows how the amount of electricity of a battery is converted into kWs if the nominal voltage is known.

Example calculation from Ah into kWs

A 24 V battery has an amount of electricity Q of 1.2 Ah. The electrical work contained in this W is determined by multiplying the voltage U with the electric charge (amount of electricity) Q

$$W = U * Q \qquad with\ u\ = \mathbf{24\ V}$$

$$and\ Q\ = I * t$$

$$= \mathbf{1.2\ Ah}$$

$$W = 24\ V * 1.2\ Ah$$

$$W = 24\ V * 1.2\ A * 1\ h$$

$$W = 24\ V * 1.2\ A * 3600\ s$$

$$\underline{\mathbf{W = 103.68\ kWs}}$$

Example calculation of kWs into Ah

The following formula can be used to convert the capacity of a capacitor from 1 kWs into 1 Ah. Here, it should be noted that the output voltage of UPSes with capacitors can be adjusted within a value range. Therefore, for a better comparison, an output voltage of 24 V is assumed.

Example: A module with a double layer capacitor shall buffer an UPS with an output voltage of $U =$ 24 V. The buffer module is specified with 2.5 kWs.

$$W = U * Q$$

$$Q = \frac{W}{U} \qquad with\ W = \mathbf{2.5\ kWs}$$

$$and\ U\ = \mathbf{24\ V}$$

$$Q = \frac{2.5\ kWs}{24\ V}$$

$$Q = \frac{2500\ V * A * s}{24\ V}$$

$$Q = \frac{2500\ A * s}{24}$$

$$Q = 104.2\ As$$

$$\underline{\mathbf{Q =\ 0.0289\ Ah}}$$

Maximum bridging time (buffering time)

To estimate the maximum buffering time, the capacity of a fully charged battery or capacitor module is considered. The buffering time depends on the following factors:

- Output voltage of power supply
- Required load current of consumer
- Capacity of battery and buffer modules

If an output voltage of 24 V is used, like in the example calculation, the available amount of electric charge Q must merely be divided by the necessary current I of the consumer to be buffered.

$$t = \frac{Q}{I}$$

For modules with a variably adjustable output voltage, like the SITOP PSU8600, the actual voltage needs to be considered during the calculation.

2.2.4 IPCs with integrated redundant AC power supply at 230V

To ensure the power supply of an IPC in case of a power supply unit failure, SIMATIC Rack PCs can be equipped with an additional redundant power supply unit. If one of the two power supply units fail, the remaining power supply unit continues to supply power for the operation of the SIMATIC IPC. The SIMATIC IPC also generates an acoustic warning signal. Via the diagnostics software SIMATIC IPC DiagBase or SIMATIC IPC DiagMonitor, the power supply units' states can be diagnosed locally on the SIMATIC IPC. Additionally, SIMATIC IPC DiagMonitor can send an email with the corresponding alarm message. A service engineer can then hot-swap the faulty power supply unit and thus restore the power supply redundancy. During the exchange of the power supply unit, the SIMATIC IPC does not require a shut-down. There is no downtime.

Figure 2-2: IPC547E-rear view, redundant power supply, module removed

Redundant power supply units are available, for example, for the following SIMATIC IPCs.

Table 2-2: IPCs with redundant power supply unit (optional)

Generation	547	647	847
G	IPC547G	-	-
E	IPC547E	-	-
D	-	IPC647D	IPC847D
C	-	IPC647C	IPC847C

Note SIMATIC IPC DiagBase can be downloaded in the entry with the entry-ID 29316343, see references \8\.

2.2.5 SIMATIC IPCs with integrated UPS at 230 V

SIMATIC Rack PCs (e.g. the IPC847D) are optionally available with an UPS that is integrated into the case of the SIMATIC IPC. This UPS continues to supply power for the IPC in the event of a failure or interruption of the power supply. Since it is integrated into the case of the SIMATIC IPC, no additional space for the montage of the UPS is required. The accompanying UPS software informs the operating system about the power supply failure. Depending on the parameterization, the operating system can be shut down after the adjustable buffering time has expired, or the SIMATIC IPC can enter into sleep mode.

2.3 Preventing data loss during a voltage failure

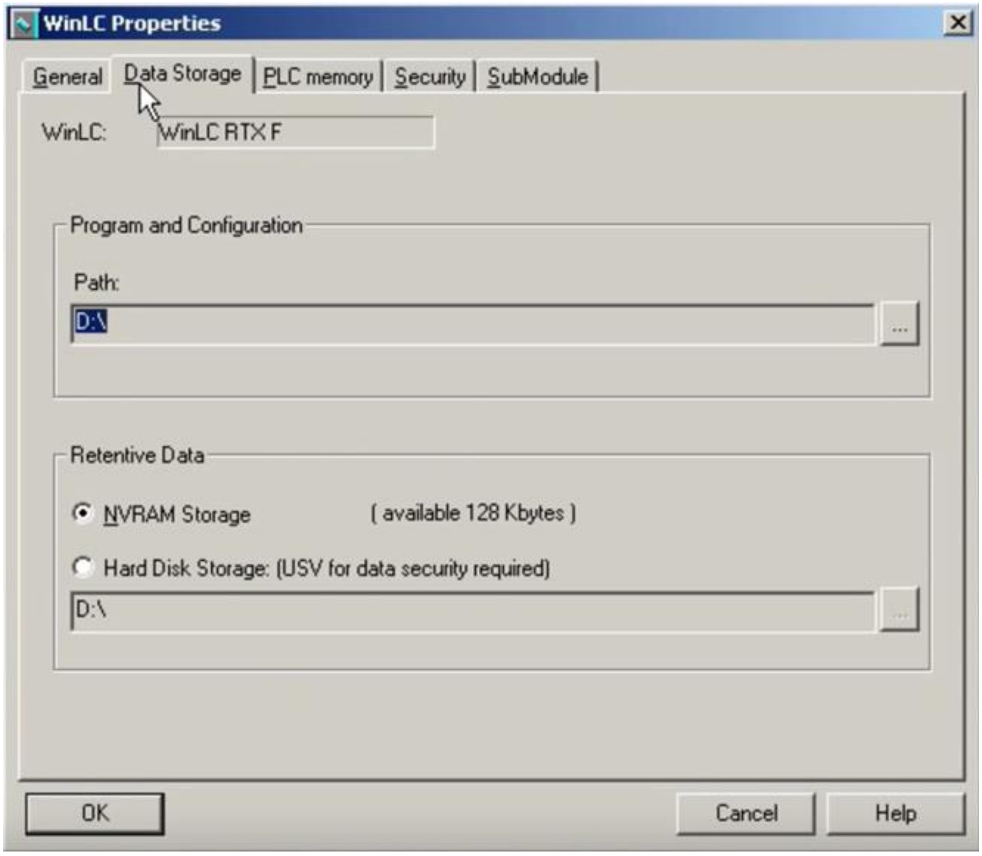
2.3.1 NVRAM and RAID

NVRAM

NVRAM stands for non-volatile memory with optional read and write access. This usually means a magneto-resistive RAM (MRAM) or a battery-buffered static RAM (SRAM). Just like conventional RAM, NVRAM can be used in read and write mode. In contrast, the data stored in an NVRAM is kept after a power failure.

Due to costs, NVRAMs in SIMATIC IPCs only have a size between 128 kByte and 512 kByte. On the NVRAM, important process data of a SIMATIC IPC software control can be stored, e.g. the state of controller tags, diagnostic messages or parts of the control program.

Figure 2-3: Settings for using the NVRAM in the WinLC software control



In the event of a power failure, the power supply sends a signals to the board electronics. It then shuts down all unnecessary components within a few milliseconds. The power supply continues to supply sufficient energy to back up the data. After power has been restored, the saved controller data are available again.

RAID

RAID controllers often contain cache memory to quickly access the data carrier of the RAID system. This applies for read as well as for write accesses. In the event of a power failure, all data need to be written safely and completely to the RAID data carrier. In HW-RAID controllers, the power required for this is supplied in the form of powerful capacitors. This ensures, that no data get lost in the event of a power failure.

Note Further information on the subject of "RAID systems in the industry" can be found in the white paper with the entry-ID 109737064, see references \5\.

2.3.2 EWF

Enhanced Write Filter (EWF) do not focus on maintaining the power supply, but on providing a write protection for the data carrier. The EWF can be activated for individual partitions as well as for entire hard disks or data carriers.

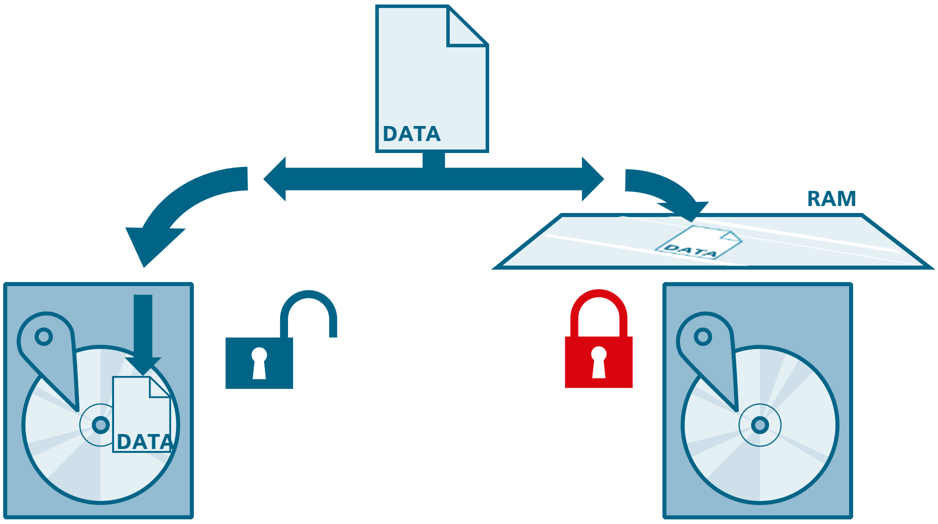
The EWF is a virtual interlayer between an application that stores data and the data carrier of the SIMATIC IPC on which the data are stored. If the EWF function has been activated, write accesses to the data carrier are not executed on the physical data carrier. Instead, the changed data are stored in the main memory of the SIMATIC IPC in the virtual interlayer. For the data-storing application, it appears as if all changes to the file system are stored in the file system, as usual.

If the SIMATIC IPC is rebooted, the data of the virtual interlayer are deleted in the main memory. After the SIMATIC IPC has been rebooted, the original contents of the data carrier are read.

This can be advantageous:

- If configuration settings are not supposed to be changed any further
- If unwanted or incomplete changes to the file system shall be prevented in the event of a power failure

Figure 2-4: Functional principle of the Enhanced Write Filter



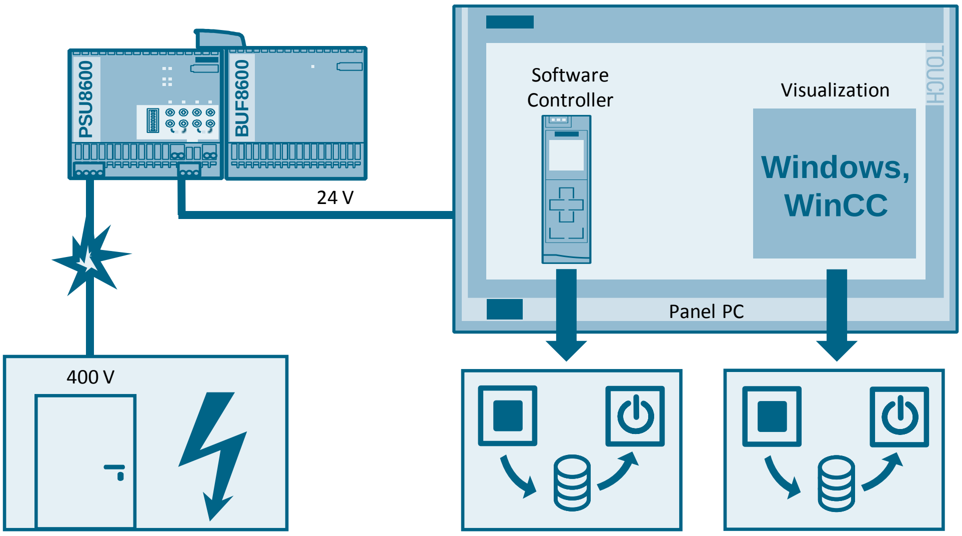
2.4 Application examples and applications

2.4.1 PSU with buffer capacitors for power failures of several seconds

If only short downtimes or voltage drops need to be bridged, a PSU with capacitor-based buffer modules can be used to stabilize the voltage. The buffer modules store electrical energy and enable an uninterruptable power supply over the course of several minutes. Compared to batteries, capacitors can be charged very quickly.

Therefore, they are suitable for restoring the readiness for the next buffering event. Via an Ethernet connection, a controller can request the state of the PSU (e.g. SITOP PSU8600) and the filling level of the energy storage. When dropping below a particular remaining quantity of energy, a SIMATIC IPC can automatically shut down.

Figure 2-5: SIMATIC IPC with 24 V power supply via a PSU with buffer capacitors



Note

An application example with

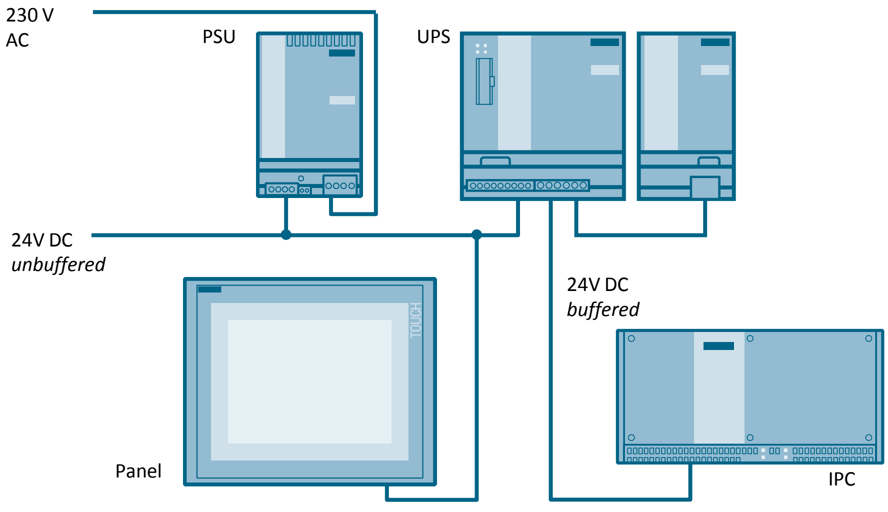
- SIMATIC IPC477D,
- SIMATIC S7-1507S
- SITOP PSU8600 and buffer module SITOP BUF8600,

Including a visualization of the PSU state is described in the entry with the entry-ID 109737962 \3\.

2.4.2 UPS with buffer batteries for longer power failures

If a SIMATIC IPC is supplied with power via an UPS or a PSU, diagnostic data and alarm messages can be evaluated by the SIMATIC IPC via standardized interfaces. An UPS of the SITOP UPS500S type, for example, offers the option to read the charging state and the operation mode of the UPS via a utility program. This is done via the USB connection between the SIMATIC IPC and the UPS. This enables defining threshold values at which particular operations are executed automatically. If the charging state of the battery drops below a certain value, the SIMATIC IPC can, for example, automatically close all applications and shut down by itself.

Figure 2-6: SIMATIC IPC with 24 V power supply via a UPS with batteries



Note

An application example with

- SIMATIC IPC
- UPS SITOP UPS500S,

including a visualization of the UPS state is described in the application example (entry-ID 52311477) \4\.

3 Summary

Depending on the consumer, PSUs with capacitors can compensate voltage fluctuations and short power failures for several minutes. Uninterrupted power supplies (UPS) with capacitors are suitable, if power failures need to be bridged over several hours.

The maximum capacity and buffering time can be increased with additional capacitors or batteries. Capacitors can be charged repeatedly and quickly, however, they do not reach the energy density of batteries. With the same volume, the latter can store higher quantities of electric energy. Batteries require a charge management to prevent deep discharging and therefore damage.

In combination with a buffered power supply or UPS, a SIMATIC IPC can automatically switch into a safe mode and shut down in the event of a power failure. Additionally, RAID controllers that are optimized for industrial applications help to securely store the data.

If a software control is executed on the SIMATIC IPC, it can back up process data in a non-volatile area of the main memory (NVRAM) in the event of a power failure. After a reboot, the data in the NVRAM continue to be available unchanged for further use through the software control. Activated Enhanced Write Filters (EWF) can prevent changes made to the file system being permanently stored on a data carrier.

Depending on the application, several of these measures can be combined. Together, they ensure a stable operation of the SIMATIC IPC and protect the system against data loss in the event of voltage fluctuations and power failures.

4 Links and references

Table 4-1 Links and references

No.	Topic
\1\	Siemens Industry Online Support https://support.industry.siemens.com
\2\	Download page of the entry https://support.industry.siemens.com/cs/ww/en/view/109739384
\3\	Application example - Shutting Down SIMATIC IPCs in the SITOP PSU8600 Buffer Mode https://support.industry.siemens.com/cs/ww/en/view/109737962
\4\	Application example - Buffering a SIMATIC IPC in the event of power failure using SITOP DC UPS https://support.industry.siemens.com/cs/ww/en/view/52311477
\5\	Industrial PC - white papers, RAID systems https://support.industry.siemens.com/cs/ww/en/view/109737064
\6\	SITOP Selection Tool https://support.industry.siemens.com/cs/ww/en/view/54418102
\7\	24 Volt power supply SITOP http://w3.siemens.com/mcms/power-supply-sitop/en/Seiten/stromversorgung-24v.aspx
\8\	SIMATIC IPC DiagBase Download https://support.industry.siemens.com/cs/ww/en/view/29316343

5 History

Table 5-1 Change history

Version	Date	Modifications
V1.0	09/2016	First version