APPLICATION NOTE | NOVEMBER 2022

Secure 24 V supply – even when failures occur in the overall power supply chain

Configurations for redundant architectures, increased power and voltage of power supplies

Plants, systems and machines, where critical states can occur if the 24 V DC supply is no longer available, should be supplied from power supply units connected in a redundant configuration. A 24 V failure can have various causes:
Fault in the line supply, cables and connections or with the power supply unit itself. Even if the power supplies are inherently extremely reliable, failures cannot be completely ruled out, e.g. as a result of line-side overvoltages. As a consequence, a redundant power supply system should be established for critical control units. Why aren't power supplies simply connected in parallel, and what does a solution based on redundancy modules look like?

SIEMENS

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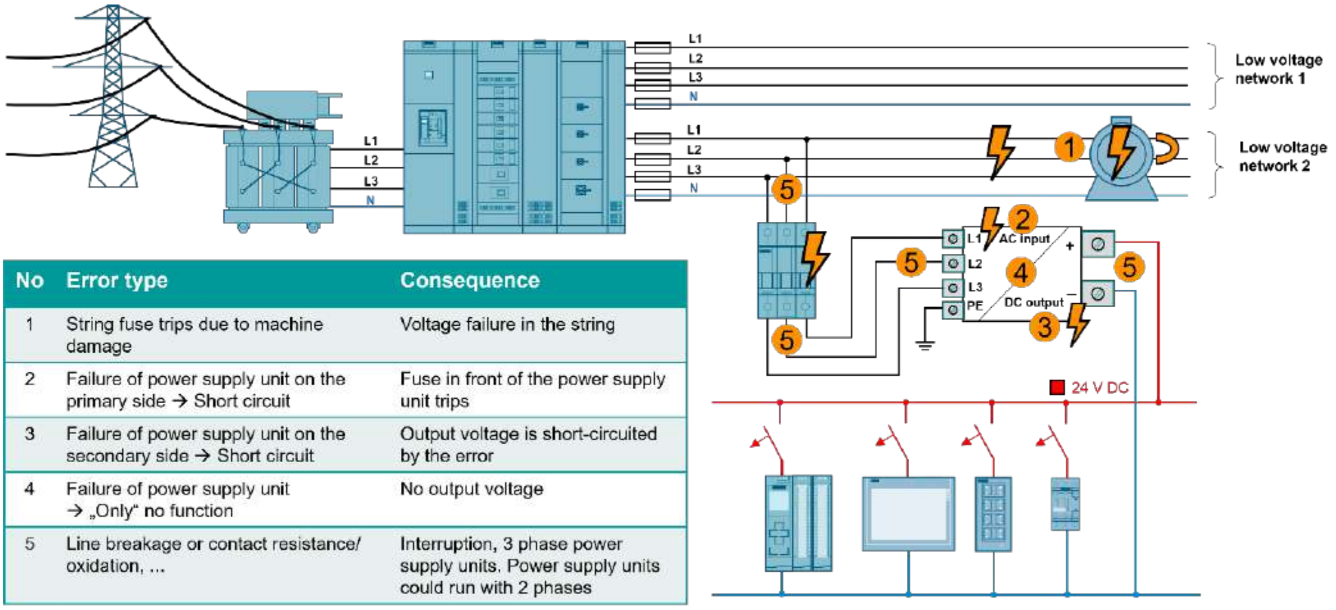
WHAT FAULTS CAN CAUSE THE 24 V SUPPLY TO FAIL?



No	Error type	Consequence
1	String fuse trips due to machine damage	Voltage failure in the string
2	Failure of power supply unit on the primary side → Short circuit	Fuse in front of the power supply unit trips
3	Failure of power supply unit on the secondary side → Short circuit	Output voltage is short-circuited by the error
4	Failure of power supply unit → „Only“ no function	No output voltage
5	Line breakage or contact resistance/ oxidation, ...	Interruption, 3 phase power supply units. Power supply units could run with 2 phases

Figure 1: Possible sources of faults in the 24 V supply chain

The remedy

The system can be structured in many ways to achieve a high degree of protection against failure – depending on the specific risks that are to be ruled out. A high degree of security on the primary side of 24 V power supplies can be achieved by using a redundant supply and the appropriate protection. Redundantly connected power supplies with their secondary sides decoupled via power semiconductors, mean that faults do not result in the failure of the complete 24 V supply.

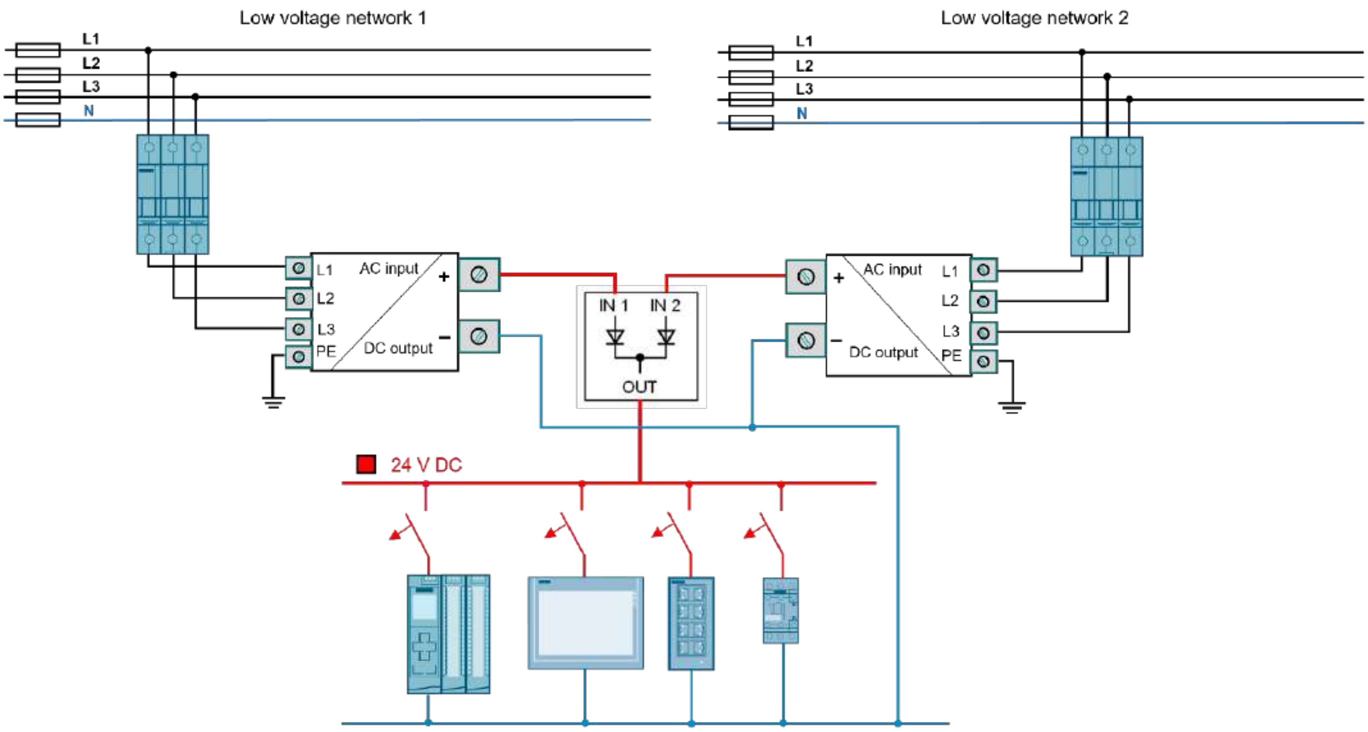


Figure 2: Configuration to prevent the complete failure of the 24 V supply chain

REDUNDANCY - SIMPLY CONNECTING IN PARALLEL IS NOT SUFFICIENT

If one of the power supplies fails, then a power supply connected in parallel directly at the 24 V output can assume the supply. However, the power supply could have a defective secondary side, which would cause a short-circuit on the 24 V side, e.g. caused by a short-circuit in the output capacitor or rectifier. This would mean that the intact power supply would also feed into the short-circuit, which would cause its 24 V supply to fail and in turn the complete 24 V supply.

Why are power supply units decoupled in a redundant configuration?

By using diodes to decouple the devices, the intact power supply is not influenced by a short-circuit of the defective device, and the connected loads and consumers are still provided with power. Some power supplies already have decoupling diodes integrated in the output circuit. However, this has a negative impact on the efficiency of the power supply as power is lost as a result of the diode conducting state voltage; this power loss is proportional to the current. To increase the efficiency, transistors can also be used to achieve the decoupling; however, in this case generally the voltage strength of the redundancy modules is less than when using diodes.

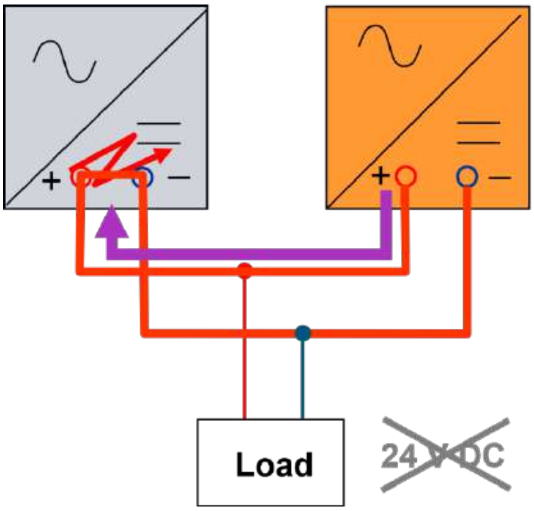


Figure 3:
Power supplies connected in parallel without decoupling: In the case of a fault, the 24 V supply can fail

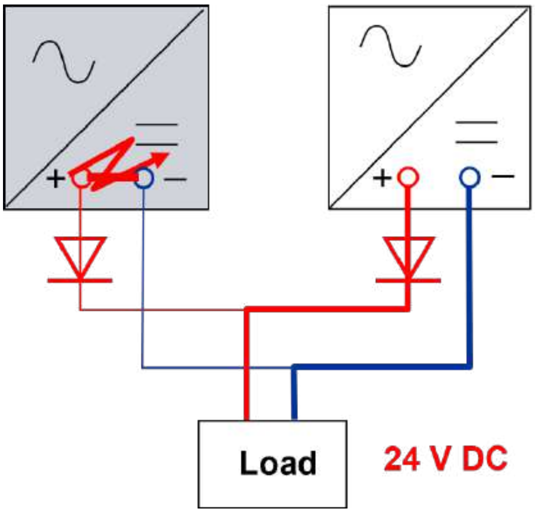


Figure 4:
Power supplies connected in parallel with decoupling: The 24 V is still available, even when one power supply develops a short-circuit

For applications, where the power supply does not have to be redundantly configured, the power loss caused by the integrated diodes is unnecessary, and it does not make sense to always use power supplies with integrated redundancy diodes. As a consequence, power supplies can be used without internal redundancy, and in critical applications, these are then used in conjunction with redundancy modules. SITOP PSE202U and RED1200 redundancy modules also operate with decoupling diodes.

1 + 1 Redundancy

In order to achieve 100% redundancy (also known as 1 + 1 redundancy), it is not permissible that the load current is higher than what one power supply unit alone can provide (Fig. 5). When one power supply unit fails, then the remaining second power supply unit supplies the complete load.

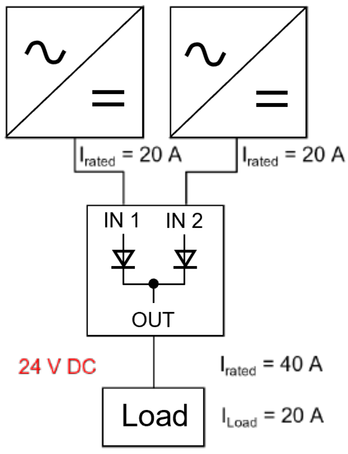


Figure 5:
Configuration for 1 + 1 redundancy with two 24 V/20 A identical power supplies to ensure the secure supply of a 20 A load

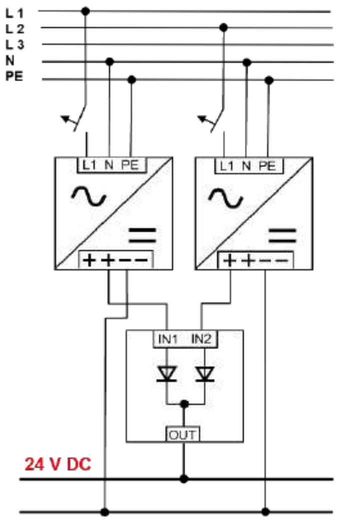


Figure 6:
If a multi-phase line supply is available, then single-phase power supply units should be supplied through different phases

Highest degree of power security: Every power supply unit has a redundancy module

SITOP redundancy modules have two diodes to decouple two power supplies. The connection to the loads/consumers is realized using one cable at the redundancy module output (Fig. 7).

To counteract the possibility of a failure of the redundancy module or the outgoing cable, a redundancy module for each power supply can also be used (Fig. 8), therefore ruling out a single point of failure. There are also redundancy modules with only one diode circuit section or one with a circuit section using transistors and with the same functionality. Redundancy modules equipped with two diode circuit sections can be considered as independent elements. Frequently, the output of double modules only comprises a single terminal and should therefore not be considered as independent elements as contact problems can occur at this output terminal.

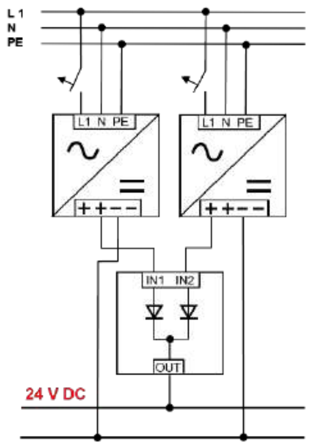


Figure 7:
Configuration with one redundancy module for two power supplies

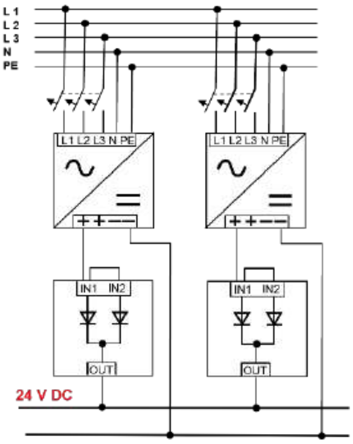


Figure 8:
Configuration with one redundancy module for one power supply. The two 24 V inputs at the redundancy modules are bridged

N + 1 redundancy through increased power

Using redundancy modules, power supplies can also be connected in parallel to increase the power rating; this also provides redundancy, in this case known as N + 1 redundancy. For example, if 60 A is required, four power supply units with 20 A rated output current can be connected in parallel using redundancy modules. This means that if one of the power supplies were to fail, three would remain functional, therefore securing the 60 A load current required. In this specific case, 3 + 1 redundancy would apply (three power supplies required, one power supply as reserve). The power supplies should be decoupled via diodes. More information is provided in Chapter "Additional applications for redundancy modules".

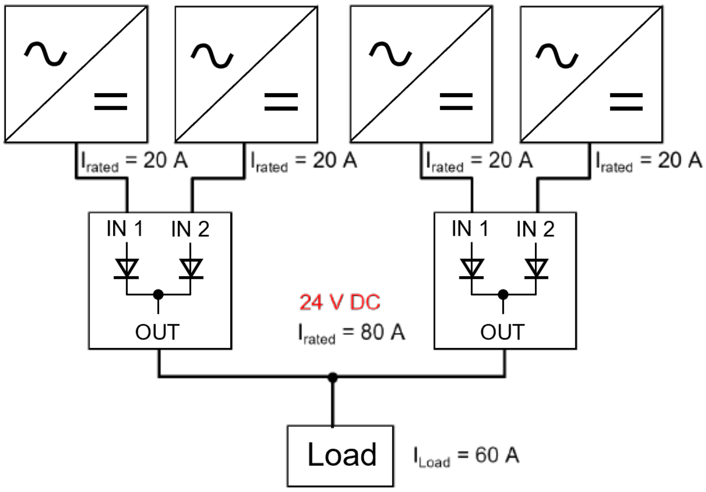


Figure 9:
Possible configuration for N + 1 redundancy with four identical 24 V/20 A power supplies to ensure the secure supply of a 60 A load

Important note regarding redundant operation

The supply via the primary side must also be redundantly configured. This means that every power supply is supplied via a separate fuse/miniature circuit breaker (Fig. 7). For a short-circuit on the primary side of a power supply, a common fuse would mean that both power supplies are disconnected from the line supply. When using 1-phase power supplies, the supply should be realized via various phases, e.g. if a three-phase line supply is available (Fig. 6). Three-phase SITOP power supplies still supply 50% of the output power at two phases - or some units, such as the SITOP PSU6200, even supply the full power.
An attempt should be made to achieve a uniform load distribution to reduce the stress on the power supply units: If one power supply has hardly any load, while the other is continuously operated at its power limit, then for the latter the thermal load has a negative impact on its service life. This can be avoided by applying the following measures:

- When using power supplies of the same type
- The same cable lengths and cross-sections between the power supplies and the redundancy module (Fig. 10)
- Same settings of the power supply output voltages (+/- 50 mV), under no-load conditions before they are connected
- When using the SITOP PSU8200 or PSU6200 product lines, the output characteristic can be set to parallel operation. The "soft" characteristic ensures an optimum load distribution (Fig. 12)

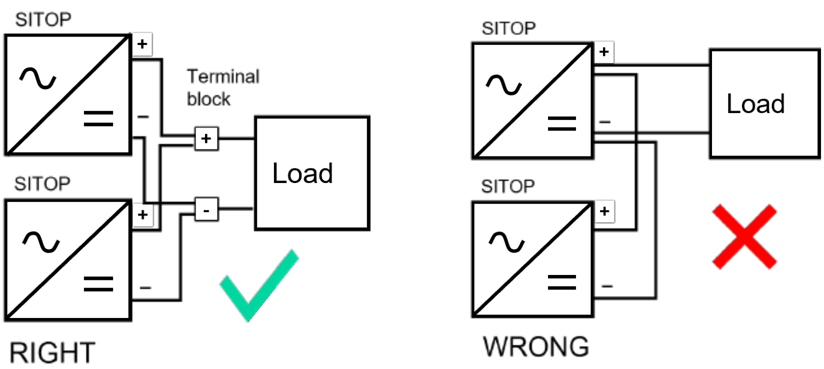


Figure 10: The same cable lengths and cross-sections ensure identical impedances after both power supplies. This is a precondition for a uniform load distribution

Load distribution for the single and parallel operation setting

Two identical SITOP power supplies set to single operation

- If the power supplies are not set to parallel operation, then the output voltage remains almost constant over the complete current range, i.e. it only decreases insignificantly (approximately 10 - 20 mV) for a higher output current (red line). As a consequence, there is no defined operating point (voltage) of the current distribution. This means that for a parallel connection, even low voltage differences can result in very different output currents of the two power supply units (area shown as blue dotted line in Fig. 11). The voltage differences occur as it is not possible to make precise adjustments using the potentiometer (50 mV differences can hardly be avoided), and also because of the slightly different resistances of the cables from the power supply to the load. As a result of thermal effects and aging, it can be assumed that even units that have been well-adjusted shift slightly and a carefully and precisely set current distribution can significantly shift.
- In the worst case scenario, one power supply provides the complete current and the other operates without any load (idling). As a consequence, the service life of the power supply operating with a full load (high temperature rise) is unnecessarily reduced.

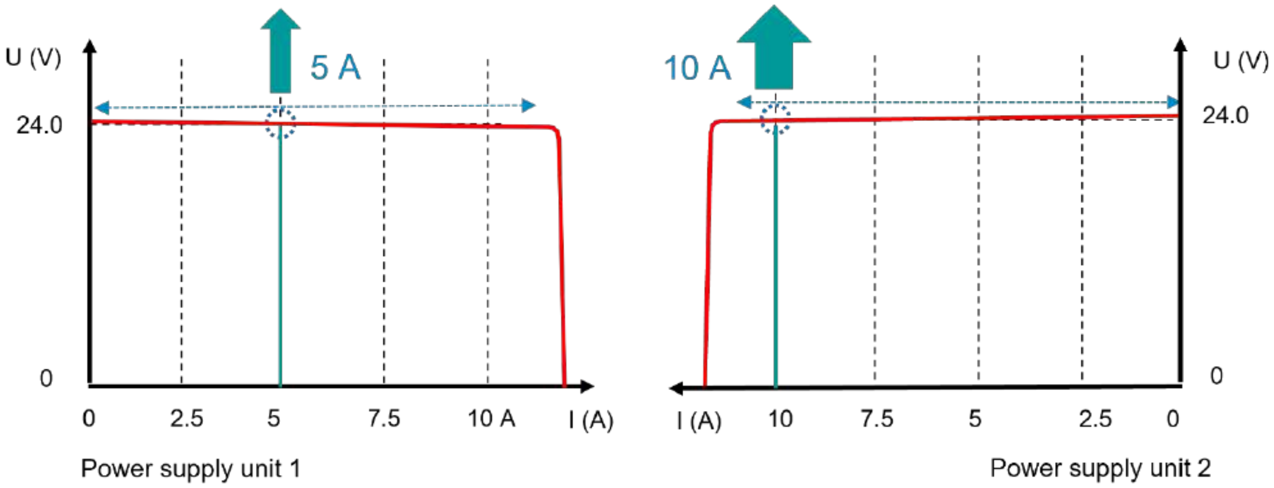


Figure 11: If both power supplies are set to single operation, i.e. to a constant voltage, then the distribution between the power supplies is probably very different. In this particular example, two power supplies are connected in parallel to increase the power. With 5 A and 10 A, the total current of 15 A is very unequally distributed.

Two identical SITOP power supplies set to parallel operation:

- For an inclined (with droop) U/I characteristic, the output voltage that is obtained depends on the current (red line). Identical SITOP power supplies have almost the same operating points. The output currents are similarly high when the output voltages are almost identical!
  Note: As the output voltages cannot be set to identical values using a potentiometer (a 50 mV difference can hardly be avoided), the same inclined U/I characteristics do not precisely coincide, and the current distribution is not precisely 50:50
- The parallel operation setting is recommended for redundant configurations and to increase the power. In both cases, the uniform load distribution reduces the stress on the power supplies and increases their service lives.
  In this case, a reduction of the power supply output voltage by e.g. 1.2 V at full load compared to no-load operation is taken into consideration. In special applications, it may be necessary to appropriately increase the no-load voltage.

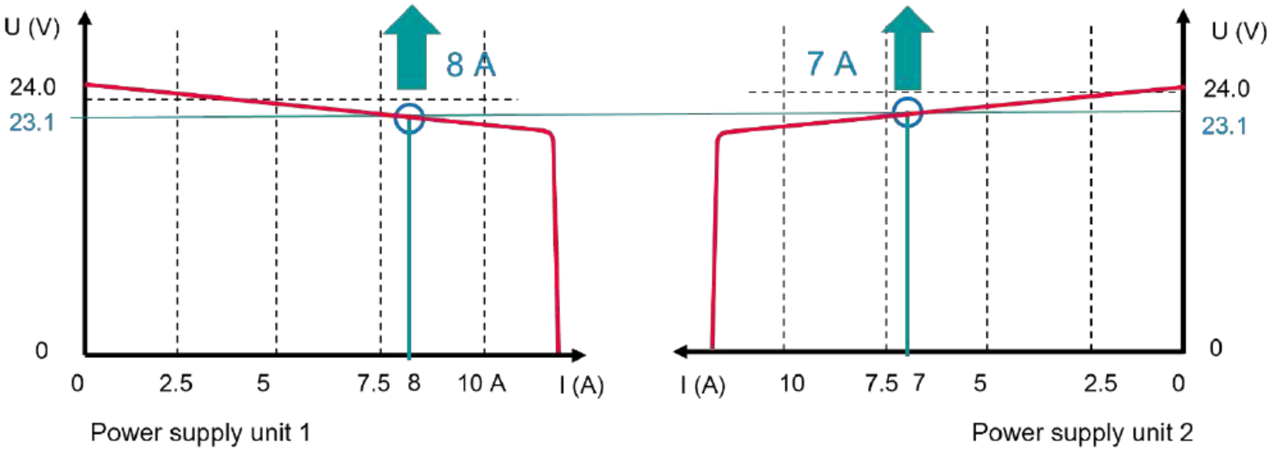


Figure 12: If both power supplies are set to parallel operation, i.e. to an inclined (droop) characteristic, then there is a very even distribution between the power supplies. In this particular example, 2 power supplies are connected in parallel to increase the power. With 8 A and 7 A, the total current of 15 A is almost symmetrically distributed.

Why is it recommended that the load is uniformly distributed over the power supplies being used?

Research carried out by Swedish physicist Svante Arrhenius in the first years of the 20th Century, led to a principal that can be applied to the aging of capacitors and, to a very limited extent, to other electronic components. As a consequence, a temperature increase of 10 degrees Celsius (or more precisely by 10 K [Kelvin]) halves the service life. This principle also applies in the inverse direction, which means that reducing the temperature by 10 K results in the service life being doubled. The focus should be on the capacitors, as these essentially define the service life of a power supply unit.
For power supply units, there is a rule of thumb that states that when operated at the rated load, capacitors installed in the unit can be approximately 30 K warmer than the ambient temperature as a result of the thermal losses of the electronics. Further, it can be assumed that the efficiency remains in a similar order of magnitude over the load range - changes of several percentage points are of no significance.
The following rough estimation is obtained by superimposing the Arrhenius formula and the rule of thumb relating to internal temperature rise:
At a specific ambient temperature and rated output current, if a power supply unit has a specified rated lifetime (service life), then it can be estimated that at 2/3 of the rated output current, the temperature inside the unit is 10 K lower, and therefore the service life is 2 x the "Rated lifetime". If the load is reduced to only 1/3 of the rated output current, then a service life of 2 x 2 x "Rated lifetime" = 4 x "Rated lifetime" can be assumed.
→ This means that any reduction in the load has a significant impact on the service life (rated lifetime). As a consequence, distributing the load is a way of increasing the service life of a complete system.

Redundant operation without load distribution

Two measures can be applied if a power supply unit should assume the total load, and the other should act as backup and remain in no-load operation. However, this approach is not recommended (see the explanation above).

1. Setting the power supply units to "standalone operation", i.e. to "Constant voltage"
2. A different setting of the output voltages, with a difference of at least 1 V: for example, power supply A is set to 25 V and power supply unit B to 24 V.

Power supply unit A with a 25 V output voltage automatically assumes the total load, and power supply unit B remains in the standby mode. This can be desirable if, for example, a power supply unit is supplied from an uninterruptible power supply (UPS) or a motor-generator-flywheel buffer and this should not be loaded unnecessarily during normal operation.

Redundant operation with power limiting according to NEC Class 2

Two requirements can be simultaneously satisfied using SITOP PSE200U NEC Class 2 redundancy modules. A redundant 24 V supply can be established on one hand, and the output power can be limited to 100 VA on the other.
Standard NEC Class 2 (National Electrical Code) for electrical equipment in the US, published by the "National Fire Protection Association" (NFPA), specifies the 100 VA limit. By limiting the power, it is assumed that there is no risk of electric shock or fire in the output circuit. As a consequence, it is not necessary to route cables in metal pipes and ducts, which is a complex and costly undertaking. This routing system has its origins in US standards, and is based on experience gained about fires over time, and the fact that wood is frequently used in civil construction. Power supplies and additional components to supply a control current circuit with NEC Class 2 approval are characterized by the fact that even in the event of a fault, the output power is limited to 100 VA. By using certified components, the costs associated for wiring and checking/testing, required for approval of the complete installation, can be significantly simplified.
Limiting the power to 100 VA is not only relevant for North America; it is also specified for several automation components in order to achieve the required fire protection safety level.
These include SCALANCE products for industrial communication and SIMATIC Industrial PCs, for example.
Additional information on this topic is provided in brochures: SCALANCE powered by SITOP and SIMATIC IPC powered by SITOP.

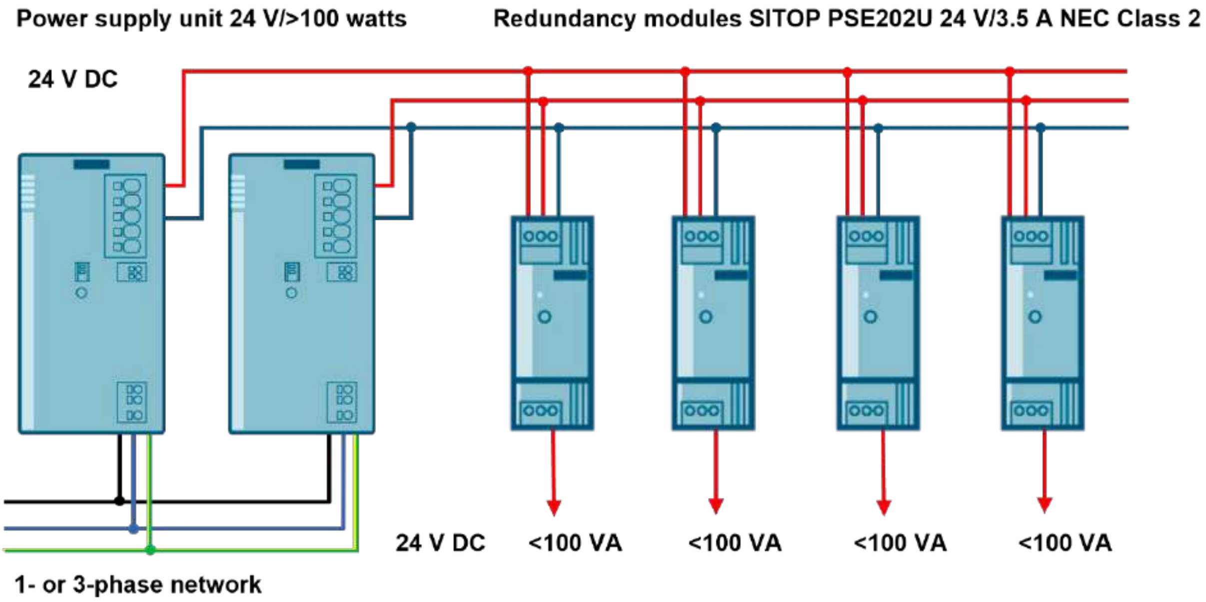


Figure 13:
Redundant configuration with simultaneous power limiting of individual 24 V branch circuits using compact SITOP PSE202U NEC Class 2 redundancy modules. In this example, two 1-phase SITOP PSU6200 24 V/20 A power supply units

Configuration without redundancy module

To configure a redundant power supply, a redundancy module is usually used to decouple the power supplies. For some automation components, a redundancy module can be omitted because they can be supplied redundantly via two 24 V inputs. The inputs are decoupled from each other and provide the required protection in the event of a power supply unit failure. For example, several SCALANCE devices have a redundant 24 V supply. In this case, the redundancy function is already integrated in the automation component.

Redundant power supply with redundancy module

Advantages

- If a load requires a NEC Class 2 supply, the PSE202U redundancy module can be used simultaneously for redundancy and power limiting according to NEC Class 2. This allows two power supply units with higher ratings to be used to power all additional 24 V loads

Disadvantages

- The cables between the redundancy module and loads are not redundantly configured (single point of failure)
- An additional redundancy module means higher costs, more space and wiring costs

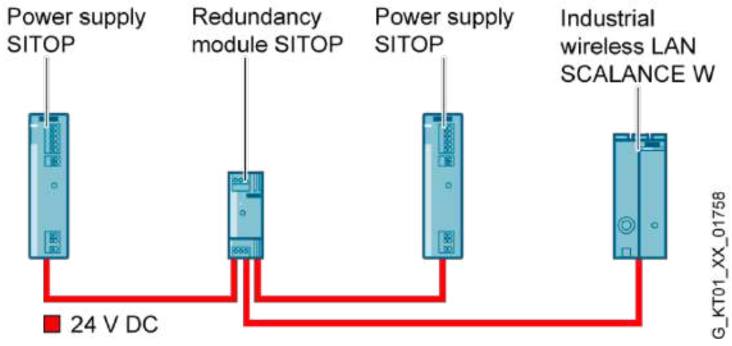


Figure 14: Redundant supply via the redundancy module

Redundant power supply without redundancy module

Advantages

- Lower costs, space and wiring costs without additional redundancy modules.
- No "single point of failure" for a 24 V supply.

Disadvantage

- If the load requires a NEC Class 2 supply, then both power supplies must meet this requirement.

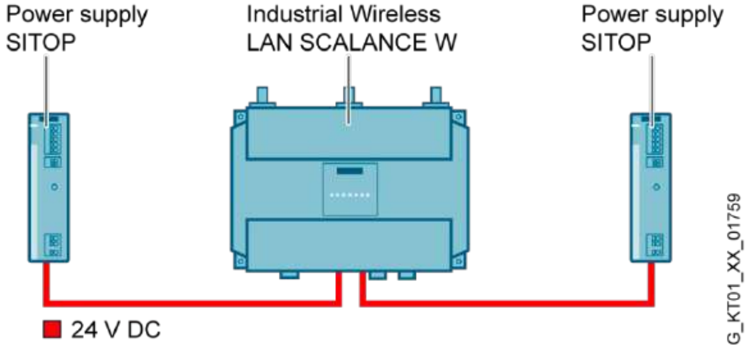


Figure 15: Redundant load supply with integrated decoupling

Signaling secures redundancy

Signaling a device failure belongs to a security concept when it comes to redundancy. This is because a defective device can be quickly replaced by a functioning device, and the redundant configuration can be quickly restored.
Evaluating the failure of a SITOP power supply depends on the SITOP redundancy module. SITOP PSE202U redundancy modules have a floating signaling contact; this responds if one of the two 24 V input voltages falls below the set threshold value. The response threshold can be set in the 24 V range.
SITOP RED1200 redundancy modules do not have a signaling contact, as they cover a much higher voltage range (12 V/24 V/48 V). As a consequence, the "Output voltage OK" signal of the specific power supply unit is evaluated, which is usually present in industrial power supplies.

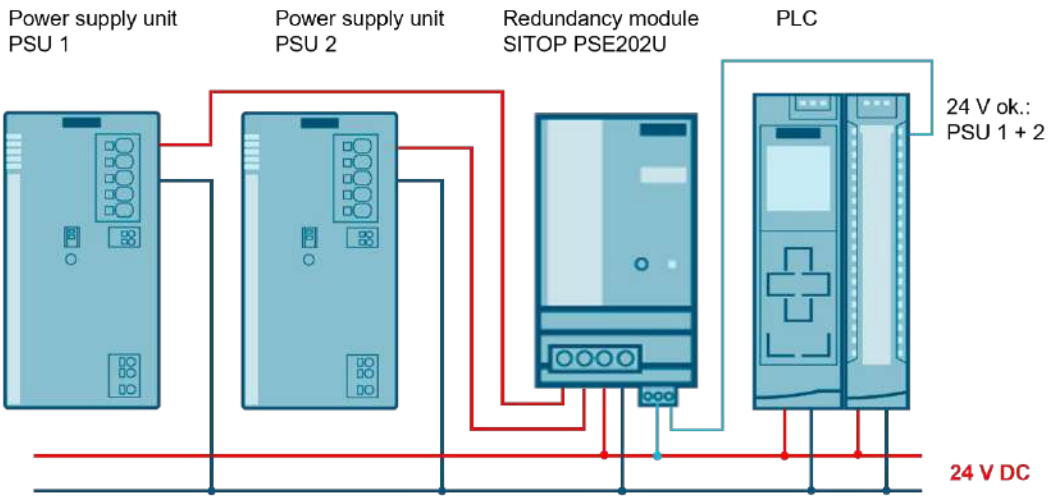


Figure 16: Monitoring the redundant 24 V supply using a SITOP PSE202U redundancy module

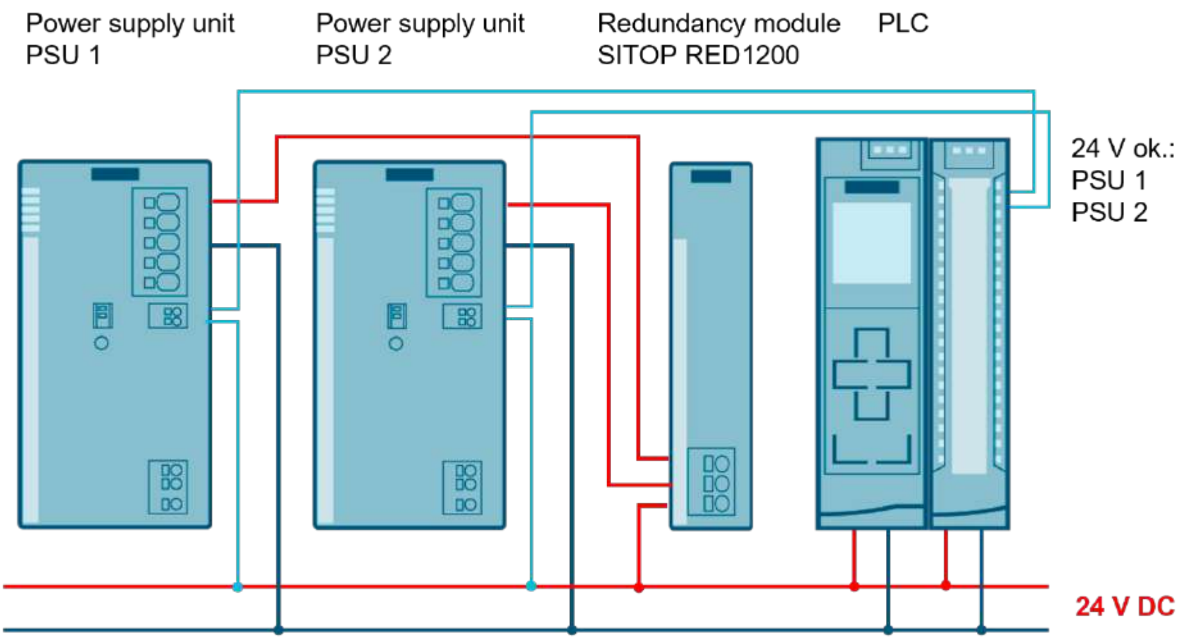


Figure 17: Monitoring the redundant 24 V supply using the power supply units. For a group fault signal, the signaling contacts of the power supply units can also be connected in series.

Additional redundancy module applications

Connecting power supply units in parallel to increase the power

Power supply units must be connected in parallel if an application requires a power which exceeds the power rating of a single power supply unit.
If 2 identical power units are connected in parallel, then from a safety perspective no additional measures are required. For 3 or more units connected in parallel, the power supply outputs must be decoupled to mitigate the theoretically possible risk of fire. This is necessary because in a worst case scenario, a component in the output section of a power unit could develop a defect that results in a short-circuit. In this case, the additional power supply units could feed their full power into the short-circuited component, and possibly cause a fire (Fig. 18). A miniature circuit breaker or a fuse represents a decoupling option; it must be dimensioned so that the value lies above the continuous rated current of the power supply (Fig. 19). As a rule of thumb, this value should be approximately 120% of the rated power supply current. This means that in normal operation, nuisance tripping is prevented, even when the overload capability of the power supplies is briefly utilized. However, due to the possibility of a fault current flowing from the functional power supply units into the defective power supply unit, component temperatures can increase until the circuit breaker trips and interrupts the fault current. As a consequence, this represents a theoretical residual fire risk. A brief voltage dip can occur if the miniatures circuit breaker or fuse does not immediately trip/rupture. However, this can also occur if the maximum current is required (3 x I rated), which the 2 power supplies that are still functional cannot provide.

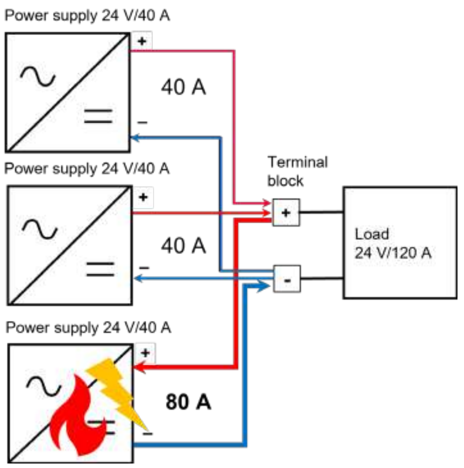


Figure 18: When increasing the power by using more than 2 power supplies, an internal short-circuit at the output can result in the defective units catching fire if the components are not dimensioned for twice the current.

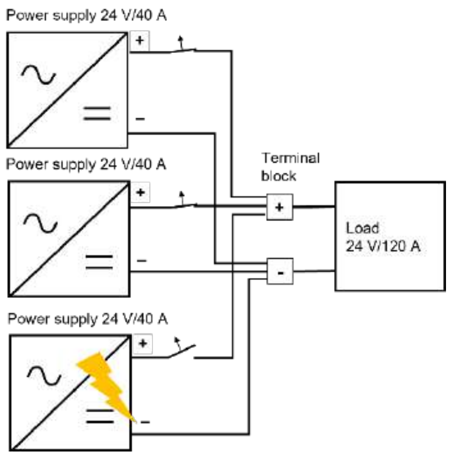


Figure 19: To protect against fire (see Fig. 18) the power supplies can be protected/fused using a fuse or a miniature circuit breaker.

Diodes or a redundancy module (Figs. 20 + 21) represent an advantageous method of decoupling. This means that a defective power supply with a short-circuit at its output is not subject to an additional load as a result of the current from the other power supply units. As a consequence, a theoretical residual fire risk can be ruled out. Further, diodes provide protection against possible overvoltages originating when motors operate in the generating mode or inductances.

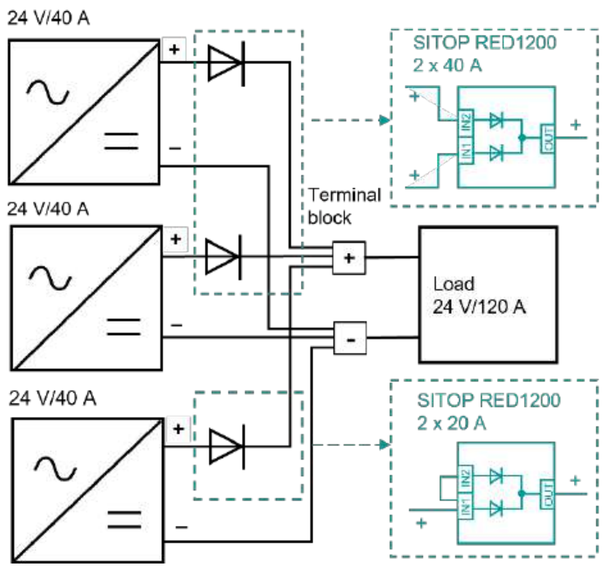


Figure 20: Protecting power supply units connected in parallel using diodes. Decoupling is the most reliable overload protection, and can be implemented using SITOP RED1200 redundancy modules, for example.

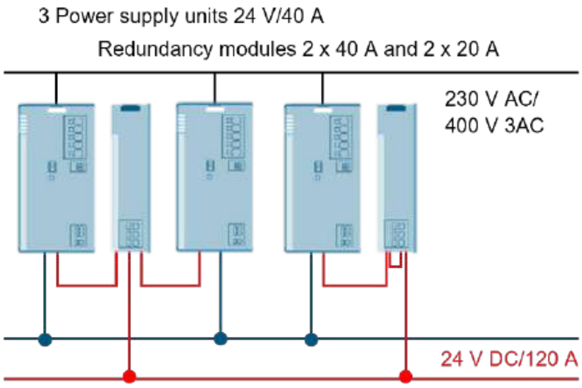


Figure 21: Configuration to increase the power to 120 A using three 24 V/40 A power supply units. They are decoupled using two SITOP RED1200 redundancy modules to provide protection against fire and overvoltage.

Notes for running up without any problems occurring

It is recommended that the units are simultaneously connected to the line supply to guarantee that they run up without any problems occurring. The risk depends on the output response and occurs for power supply units with the Hiccup mode, for example.
If the power supply units are not simultaneously switched on, then the unit that starts first must initially supply the complete load, which lies far above its rated current. As a consequence, the 1st power supply unit would shut down again before the 2nd is switched-in and provides support with its output current. The 2nd power supply would then be connected to the excessively large load and would also shut down before the first starts again. In the worst case scenario, one power supply attempts to run up while the other is presently paused.

This problem can be resolved by using power supply units with a continuous UI characteristic and/or constant current characteristic (Fig. 11). Even when subject to a very high overload condition, these units do not completely shutdown, but still continue to supply their maximum current. The power supply unit remains active, although the output voltage can drop down to 0 V. The system always reliably starts although some delay is incurred when power supply units connected in parallel run up.

Connecting power supply units in series

If output voltages are required that can no longer be provided from a single power supply, higher voltages can be achieved by connecting units in series. However, when doing this, several aspects have to be taken into consideration:

Protection against electric shock!

Not every power supply unit is suitable for a series connection!
Power supply units generally used in automation systems provide a safety extra-low voltage in the 24 V range or occasionally 48 V range. If power supply units are connected in series, then the 60 V threshold is possibly exceeded, which represents the touch limit for non-hazardous currents flowing through the body. This means that from this voltage and higher, the wiring must be handled as if it is at a hazardous line voltage level. Above 60 V, it must be clarified with the power supply manufacturer whether the internal safety clearances, filter capacitors and other components permit a series connection up to the required total voltage. Even if the safety clearances are fulfilled, signal relay outputs and operator control elements, for example adjustment potentiometers, must be carefully taken into consideration. The "power-good" signal should not be evaluated if the safety clearances are not adequate. An insulated screwdriver must always be used when adjusting the output voltage or actuating operator control elements, so that safety clearances that are possibly violated do not result in a potential risk for persons.

Protecting high efficiency switched-mode power supplies

The current load of internal components in the power supplies must also be considered.
With the introduction of new high-efficiency circuit topologies, such as resonant circuits, passive rectifier diodes in output circuits are replaced by more efficient, actively controlled transistors. These are known as synchronous rectifiers.
In addition to increasing the efficiency, the envelope dimensions are also reduced. This is the reason that this technology is increasingly establishing itself in units with output power ratings of about 500 W. However, an undesirable effect can occur if power supply units equipped with synchronous rectifiers are connected in series: If the power supply units do not simultaneously run up, or if one of the units shuts down as a result of a high load or its line feeder cable is interrupted, then the remaining power supply unit supplies the load. This load current now inevitably also flows through the inactive power supply unit, but instead of flowing through diode rectifiers with their correspondingly large heat sinks, which were predominantly used in earlier designs, it flows through the transistors of the more efficient synchronous rectifiers.
However, as the power unit is not operational, the transistors are also not controlled, the efficiency advantages cannot be utilized and the amount of energy lost in these transistors is up to 10 times higher than in normal active operation. The transistor cooling is only dimensioned for normal operation, so that thermal overload occurs, and it is highly probable that the inactive power supply unit is damaged. Diodes, which are connected in an antiparallel configuration to the outputs, provide protection against this (Fig. 22). In this particular scenario, the diodes conduct the current, therefore protecting the power supply unit that is switched off from destruction.

Protection against voltage feedback

If the power supply units feed loads in the application that can feedback energy, e.g. motors that are electrically braked, then a diode must be connected in series (Fig. 23). Otherwise, when feedback occurs the total output voltage is increased. The distribution of the energy that is fed to the individual power units connected in series depends on the tolerance of the components in the power supply units and is therefore not precisely defined. This can very easily result in a voltage overload, and therefore damage to the power supply unit, and should be absolutely ruled out.

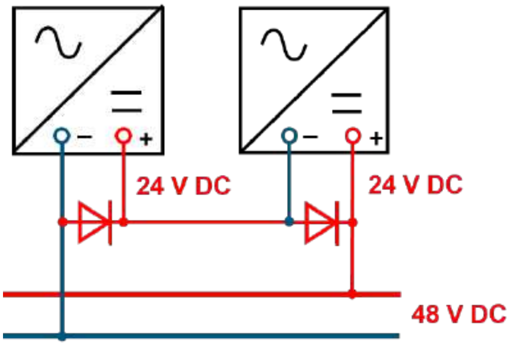


Figure 22: Two power supplies connected in series increase the output voltage, for example, from 24 V to 48 V. High efficiency switched-mode power supplies with resonance circuits should be protected using diodes connected in an antiparallel configuration at the output.

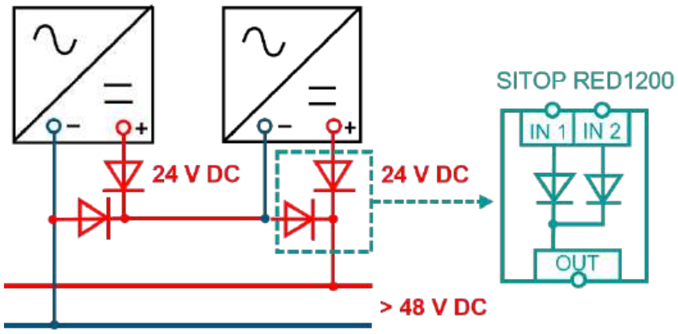


Figure 23: A diode at the positive output of every power supply provides protection against overvoltages from the application. The simplest way of implementing the diode circuit is to use a SITOP RED1200 redundancy module.

Note regarding the optimum use of an RED1200 redundancy module

SITOP RED1200 redundancy modules comprise 2 diodes. For a higher current demand, inputs 1 and 2 can be bridged so that the diodes are connected in parallel. For example, a RED1200 2 x 20 A can be used for 40 A (see also Fig. 20 + 21). This also functions without a bridge having to be inserted. This means that only one diode circuit section can be subject to a 40 A load as long as a load is not applied to the second one. The total load is the decisive factor along with the resulting total power loss (thermal loss), which is dissipated through a common heat sink. Using this configuration, for the diode circuit shown in Fig. 20, it is possible to use one RED1200 redundancy module with 2 x 20 A, although 40 A flows in each diode circuit section. This is because in this particular application, 40 A only ever flows through one diode, but never through both simultaneously: The diode in parallel with the output is only subject to a load when switching on. The diode with its anode directly connected to the positive output of the power supply unit, i.e. in the direction of current flow, is then subject to a load in operation.

Protecting power supply units against critical voltages

Most of the power units used in automation systems are designed so that persons can come into contact with the output voltage (SELV – Safety Extra Low Voltage). In the design phase and for the safety acceptance of the units, corresponding safety clearances are maintained and only components, such as transformers, are used with adequate voltage strength. When connecting power supply outputs in series, if a total output voltage is reached that exceeds the limit value for non-hazardous touch voltages for humans (60 V DC), then the safety clearances in the power supply units are generally no longer sufficient for the changed potential relationships.
To facilitate a correct configuration, it is necessary to ground the foot point (root point) of the series circuit (Fig. 24). The grounding results in an additional protection, which compensates for the requirements in compliance with the standard due to the changed potential relationships.

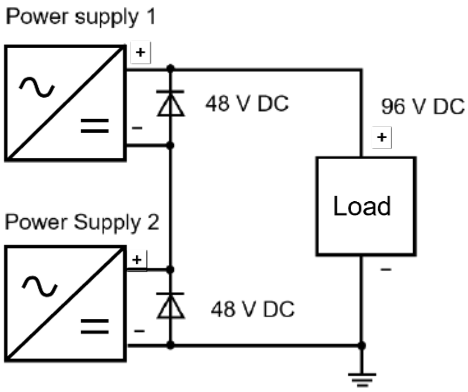


Fig. 24: When connecting power supplies in series to create voltages higher than 60 V DC, the grounding provides protection for the components in the power supply units. In this example, to protect two 48 V units.

Connecting uninterruptible power supplies in series

A 24 V SITOP UPS1600 uninterruptible power supply with UPS1100 or BAT1600 battery modules can be expanded to create a 48 V output voltage by connecting two identical DC-UPS configurations in series (Fig. 25). The following measures should be taken into consideration:

- The power supplies should be switched on together in order that the two uninterruptible power supplies run-up, as far as possible, simultaneously.
- A slight time offset between the two DC-UPS configurations when running up cannot be prevented, which means that a diode must be connected in an antiparallel configuration in parallel to the DC-UPS module outputs (see Fig. 25: Diodes at "IN1"). The reason is the same as described in Chapter "Protecting high efficiency switched-mode power supply units". Further, the diode protects the UPS1600, if, after longer buffer operation, a battery has been fully discharged and the other is still providing a voltage. In this case, the inactive DC-UPS module would be unnecessarily loaded by the 24V voltage of the still active DC-UPS module.
- A diode should be connected in the direction of current flow at the + 24V output of the DC-UPS module (see Fig. 25: Diodes at "IN2"). The diode protects against high voltages caused by loads that feed back energy, such as described in Chapter "Protecting against voltage feedback".
- After a longer period of buffer operation, one of the two battery modules will have a discharged faster than the other, and 48 V will no longer be connected to the load. This means that the load should also not be damaged when only 24 V is connected. Otherwise, measures must be applied to protect the 48 V load.
- The simplest way of implementing the diode combination is to use a redundancy module for each UPS1600

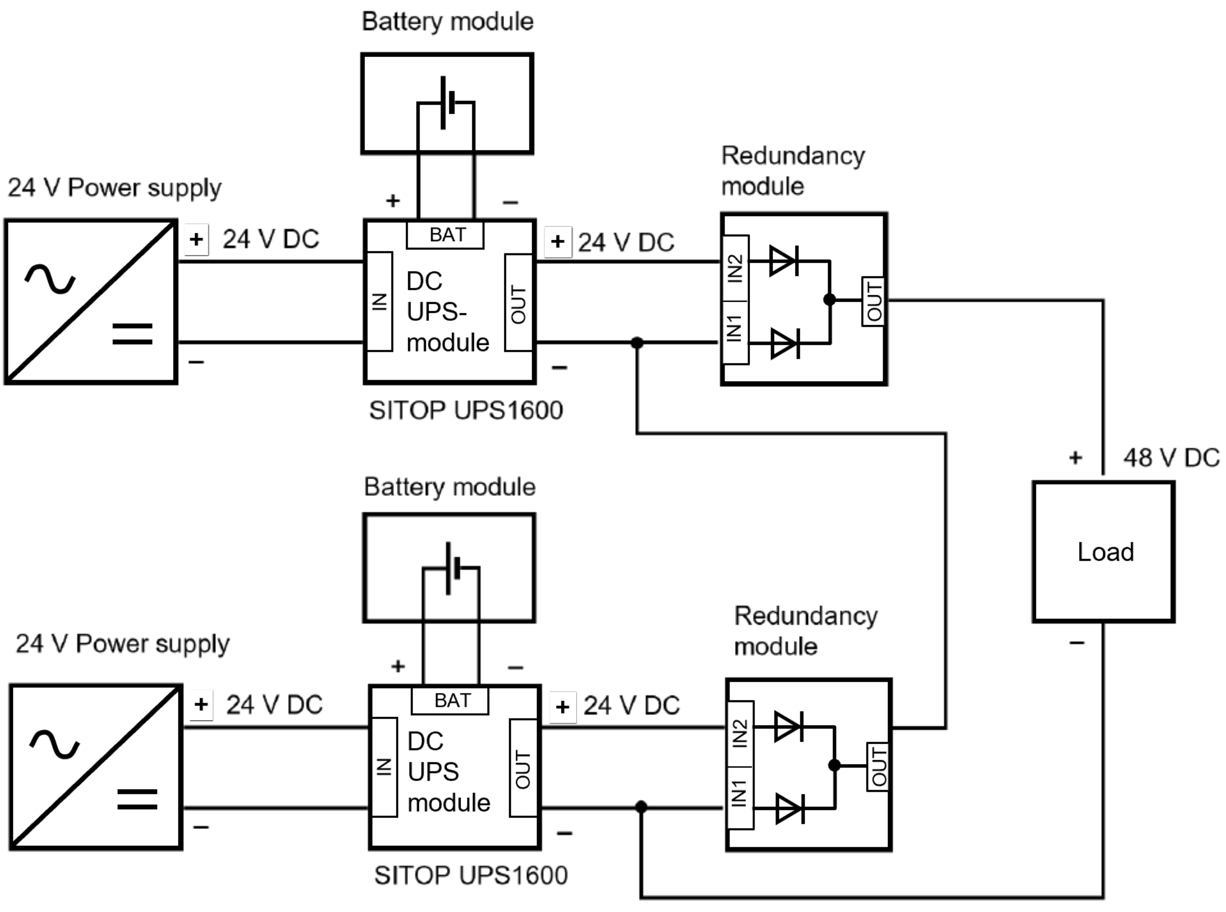


Figure 25: Two identical 24 V DC-UPS configurations connected in series for an uninterruptible 48 V DC

Cost-effective solution to buffer the 24 V for individual loads

A cost-effective solution can be configured using a redundancy module and a buffer module so that individual loads can be buffered for as long as possible with 24 V, e.g. an industrial PC, when the power fails. In this case (Fig. 26) if the power fails, the buffer module only supplies the IPC, as the diodes in the redundancy module disconnect uncritical loads from the buffer current. As a consequence, the full energy content of the buffer module is available to supply the critical load. For brief power failures, the buffer time that is achieved can be adequate to continue to operate the machine without incurring a longer interruption.

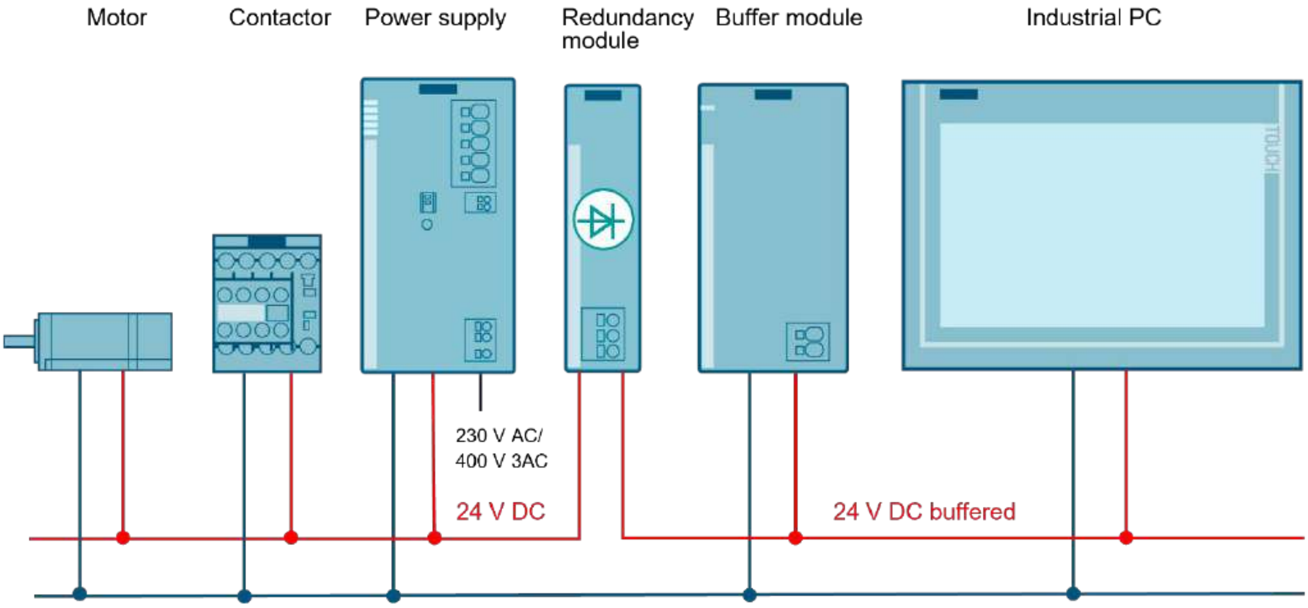


Figure 26: For a power failure, the redundancy module decouples uncritical loads from the buffer module so that critical loads (in this case an industrial PC) can be supplied with 24 V for as long as possible.

Why do SITOP redundancy modules operate with diodes?

We frequently get asked why we use diodes in our SITOP redundancy modules, and not MOSFETs for example (Metal Oxide Semiconductor Field-Effect Transistor).
MOSFETs are characterized by their low power losses, assuming that types are selected whose voltage strength is relatively low (e.g. 40 – 60 V). However, the objective of a redundancy module is to be as rugged as possible, which means that it must have an appropriately high voltage strength. If this is not the case, then interference voltages, which are either coupled in or induced as a result of switching operations, can damage components in the redundancy module. Further, if 2 power supplies are incorrectly connected with one another via redundancy modules, then there is a risk that twice the output voltage of a power supply will be applied to one of the diodes (or MOSFETs). If you wish to connect two 48 V devices in parallel, but inadvertently interchange plus and minus at one of the power supplies, then 96 V is applied (at the right in Fig. 27). If the components in the redundancy module are only dimensioned for a rated voltage of 60 V for example, then they will fail. It is even more dangerous if components do not immediately fail due to an overload, but only incur some preliminary damage. From experience, components that have incurred preliminary damage fail after a short usage time, anywhere from several days to weeks. In the worst case scenario, they fail in operation and not while being commissioned. It is very complex to design an efficient redundancy module equipped with MOSFETs and at the same time achieve a voltage strength significantly above 96 V, which is why diodes offer a good alternative for this type of application.
On the other hand, SITOP redundancy modules have a high voltage strength, and can even withstand being connected with an incorrect polarity. SITOP RED1200 redundancy modules have a reverse voltage strength of 110 V, for example.

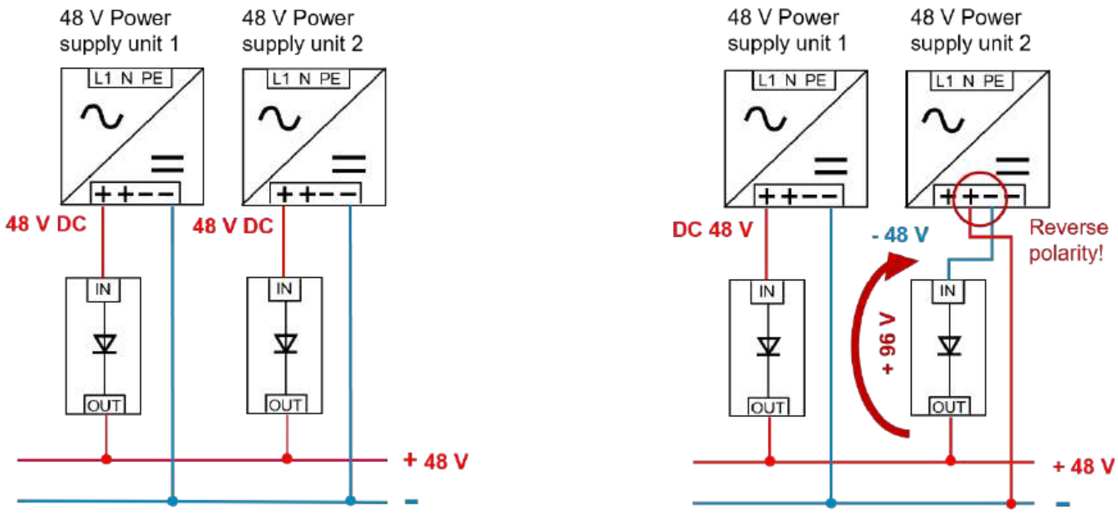


Figure 27
Left: Two 48 V power supplies correctly wired up in parallel via a redundancy module.
Right: For an incorrect polarity at one of the power supply outputs, instead of a parallel connection, a type of series connection is obtained where twice the output voltage is applied to a redundancy module. In this case, when 96 V is applied, redundancy modules with a lower voltage strength could immediately fail, or some time later in operation.

Technical data of SITOP redundancy modules

Technical data of redundancy modules SITOP PSE202U			
	24 V/10 A	**24 V/40 A**	**24 V/NEC Class2**
Order No.	6EP1964-2BA00	6EP1961-3BA21	6EP1962-2BA00
Brief function description	Decoupling of 2 power supplies up to 5 A or one power supply up to 10 A	Decoupling of 2 power supplies 5 A up to 20 A or one power supply up to 40 A	Decoupling and limiting of the output to Class2 limit (100 VA) of 2 power supplies 5 to 40 A
Rated input voltage	24 V DC	24 V DC	24 V DC
– Range	19...29 V DC	24...28.8 V DC	19...29 V DC
Output voltage	U_{in} - 0.5 V	U_{in} - 0.5 V	U_{in} - 0.5 V
Rated output current	10 A (maximum total current)	40 A (maximum total current)	3.5 A (max. 8 A total current in the case of fault acc. to NEC Class2)
Reverse-voltage strength	52 V DC	52 V DC	52 V DC
Status indicator	LED (green/red) for "Supplies 1 and 2 and output o.k."		
Signaling	Floating relay contacts (changeover contact) for "Supplies 1 and 2 and output o.k."		
Contact rating	6 A/ AC 42 V, 30 V DC	8 A/ AC 240 V, 24 V DC	6 A/ AC 42 V, 30 V DC
Settings	Switching threshold for "Supplies 1 and 2 o.k.", can be set from 20 to 25 V (+/- 0.5 V)		
Efficiency at rated values, approx.	97%	97%	95%
Degree of protection (EN 60529)	IP20	IP20	IP20
Ambient temperature	-20...+70 °C	0...+60 °C	-20...+70 °C
Dimensions (W x H x D) in mm	30 x 80 x 100	70 x 125 x 125	30 x 80 x 100
Weight, approx.	0.125 kg	0.5 kg	0.125 kg
Connections - +24 V and 0 V	0.5 to 2.5 mm^2	0.33 to 10 mm^2	0.5 to 2.5 mm^2
– Relay contact	0.5 to 2.5 mm^2	0.5 to 2.5 mm^2	0.5 to 2.5 mm^2
Certifications	CE, cULus	CE, cULus, DNV GL, ABS	CE, cULus, NEC Class 2

Technical data of redundancy modules SITOP RED1200			
	12 V, 24 V, 48 V DC/20 A	**12 V, 24 V, 48 V DC/40 A**	**12 V, 24 V, 48 V DC/80 A**
Article No.	6EP4346-7RB00-0AX0	6EP4347-7RB00-0AX0	6EP4348-7RB00-0AX0
Article No. Ex version		6EP4347-7RC00-0AX0	
Brief function description	Decoupling of two 24 V to 48 V power supplies with output currents up to 20 A or one power supply up to 40 A for each redundancy module		
Rated input voltage	24 V DC, 48 V DC		
– Range	24...56 V DC		
Output voltage	U_{in} – approx. 0.6 V		
Rated output current	20 A (maximum total current)	40 A (maximum total current)	80 A (maximum total current)
Reverse-voltage strength	110 V DC	110 V DC	110 V DC
Status indicator, signaling	No	No	No
Efficiency at rated values, approx.	97.5%	97.5%	97.5%
Degree of protection (EN 60529)	IP20	IP20	IP20
Ambient temperature	-30...+70 °C	-30...+70 °C	-30...+70 °C
Dimensions (W x H x D) in mm	35 x 135 x 125	45 x 135 x 125	45 x 135 x 155
Weight, approx.	0.47 kg	0.51 kg	1.01 kg
Input and output connections	Push-in terminals 0.5 ... 6 mm^2	Push-in terminals 0.5 ... 16 mm^2	
Certifications	CE, cULus, being prepared: DNV GL, ABS. Ex version: ATEX, IECEx, UKEx		

The information in this Application Note is as of November 2022.

Publisher
Siemens AG
Digital Industries
Gleiwitzer Str. 555
90475 Nuremberg
Germany

Support
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