

## Safety of AC power supplies fed with DC voltage AC Power Supplies with DC Feeds



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In the last two decades switch power mode supply technology has established itself as the technology for supplying servers, laptops, lights, machinery, industrial machinery and building automation systems.

It is likely that the technology can handle all the world's existing AC voltages. In certain cases it is necessary to supply DC voltage instead of AC voltage – some consider this to be no problem, others warn that this is very sensitive. An assessment of the current situation.



1: AC power supply fed with DC voltage. PULS DC/DC converters and DC versions can cope with a high-energy DC power supply even in the event of a fault.

Easy-to-use switch mode power supplies are here to stay in both industry and in building services engineering. DC voltages can be easily buffered using batteries immediately providing a secure supply of electricity – is it that easy?

Previous power supplies always worked with a mains transformer. The generation of the DC voltage, regulated or unregulated, took place on the secondary

side. However, with switch mode power supplies rectification takes place on the primary side instead, and then the DC voltage is cut at a high frequency and transmitted to the secondary side via a small high frequency transformer (Fig. 2). This technique permits a large input voltage range as well as the regulation of a load current of 0 ... 100 % in continuous operation.

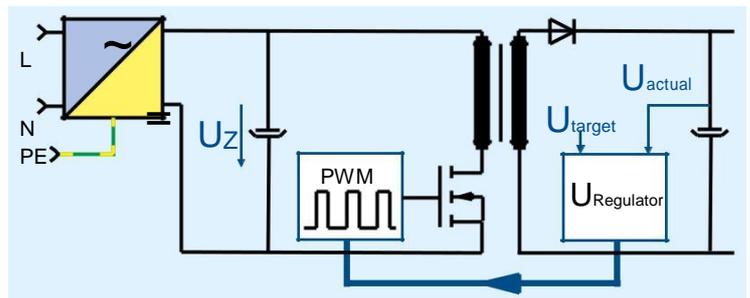
If one considers the principle of the input circuit of a switch mode power supply, the first thing one notices is the mains rectifier. So what happens if a DC voltage is applied instead of an AC voltage? If everything runs „accurately“ virtually every switch mode power supply will work with either DC or AC voltage at the input. However, in the event of a fault a switch mode power supply unsuitable for DC operation may result in a fire as the handling of high DC voltages is far more dangerous than handling AC voltages.

### DC supply voltage

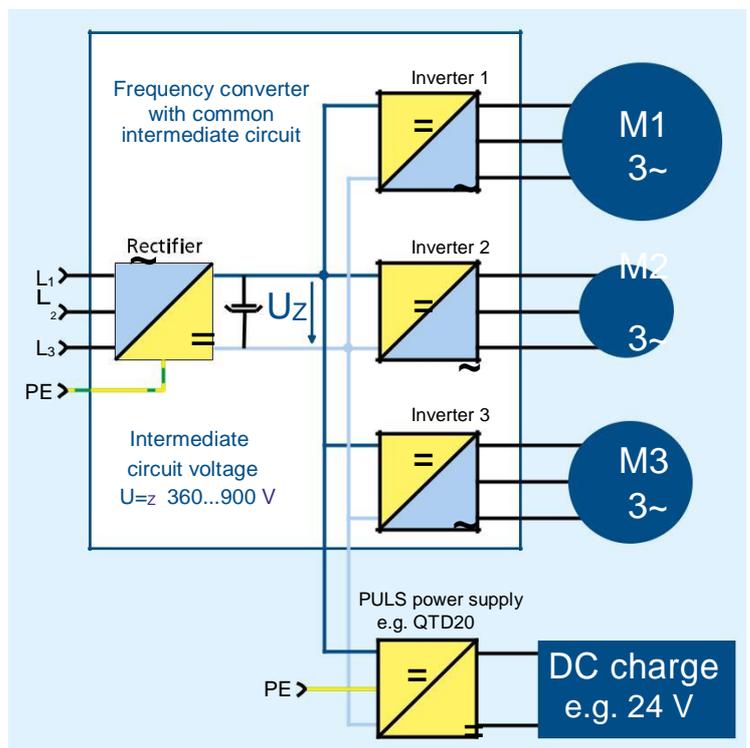
Why operate a power supply on DC voltage when it is actually designed for an AC input voltage? There are many applications to choose from:

1. When using several frequency converters (FC) or servo amplifier a power rectifier delivers the intermediate circuit voltage in the range 360 ... 900VDC for several FCs. This DC voltage can also be used to feed switch mode power supplies, which can be of great advantage (Fig 3). In the event of a power failure, the system or machine is immediately moved to a rest position. The motors work as generators and transform kinetic energy into electrical energy, in the process feeding the intermediate circuit and ensuring that without UPS the power supply and the controller is fed until an orderly stop condition is reached.
2. With a redundant electrical supply the power supply is fed from the high-voltage grid and a second power supply is fed from a battery (Fig 4). Both power supplies are connected in parallel. Voltage is supplied to the load at all times.
3. Systems that are always supplied with, for example, 220VDC from battery or other DC power source.

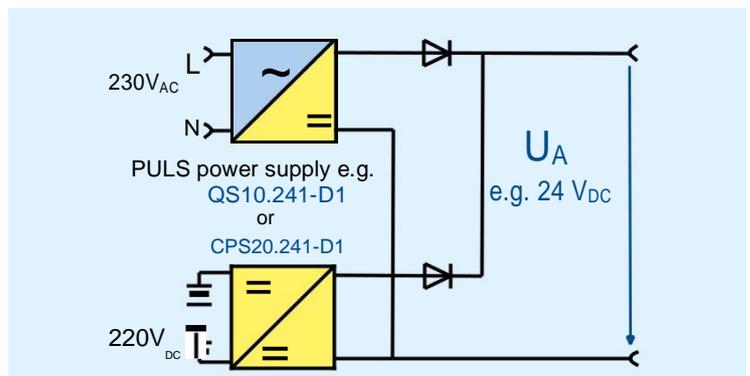
In all of these cases the DC voltage source is capable of supplying high currents. In the event of a fault a short or overcurrent must be safely switched off. Conditions that can be reliably dealt with using quartz sand filled lead fuses in an AC voltage, present a significant challenge for DC voltages.



2: Principle of a switch mode power supply without an input filter.



3: Frequency converter system with an intermediate circuit voltage, but multiple inverters and power supplies, powered from an intermediate circuit voltage.



4: Redundant power supply: Normally from a high voltage current network, supplied from a battery in the event of a power failure.

## Where does the problem lie?

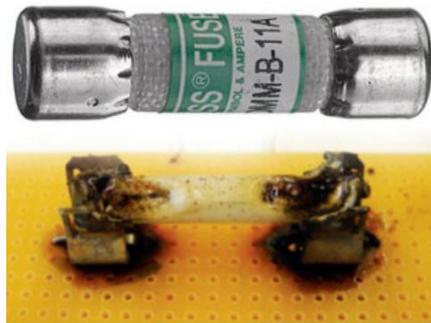
To reiterate: The „normal case“ is not the problem. However, technicians who carefully plan for every eventuality always bear in mind the exceptional case. This conveys no insurance for the „normal case“, rather for the „accident“. Under normal circumstances a power supply that is designed for AC operation can also be used for a DC supply. The question is, however, is the exceptional case also covered? Most providers of switch mode power supplies would have to answer this question with a categorical NO.

## Operation of an FC-intermediate circuit

The intermediate circuit voltage of frequency converters is superimposed by steep edge voltages with high AC voltages with respect to ground (common mode voltage). The power supply has to deal with what can usually only be achieved with a special input filter.

## Lead fuses:

Switch mode power supplies are provided with built-in lead fuses as a final precaution in the event of a fault. This raises the question: Is this lead fuse able to switch off a high DC voltage in the event of a short or overload current? At first, the event of a short-circuit case appears problematic. But this is not necessarily so. For example, it only becomes tricky if up to three times the rated current flows through the lead fuse. With this type of fault a fuse that is not suitable for DC voltage cannot open reliably. The resulting heat development could also cause a fire (Fig. 5).



5: Above: Expensive lead fuse to protect switch mode power supplies even in the worst cases, below a type of fuse that works with an AC power supply but not at high DC voltage.

Also interesting is the fact that for DC voltages the higher the current, the more critical the shut-off performance of the lead fuse. Common integrated fuses can only be used up to a rating of 4A with AC and DC input voltages. At higher currents the DC operation above 150VDC is not allowed. In the case of 230VAC the voltage after the rectifier is already around 320VDC, frequency converters intermediate circuit voltages for three-phase applications are in the range of 360...900VDC, depending on the mains voltage.

This problem has been recognised. The circumstances which define what power supply with a DC voltage is precisely described in current UL documentation (practical application guide). The lead fuse used must be able to reliably handle both short and overload currents without producing temperatures high enough to endanger the surroundings.



See in the video what happens when you operate an unsuitable AC-fuse with more than 300VDC and 15A.

## Reliable PULS solution

A power supply, which is also suitable for a high DC input voltage must have two specific resources:

- Suitable input filter to filter out high common-mode voltages to ground
- Installed with UL and also IEC approved lead fuses

PULS offers an extensive product portfolio of power supplies with power capacities from 15 watts to 480 watts and with which the DC supply is reliable and proven possible. The units are approved in regard for DC operation from both the dimensioning of clearances and creepage distances as well as from the selection of input fuses.

Up to 900VDC is required to also tolerate the intermediate circuit voltage of a three-phase frequency converter. The units in the QS Series cannot achieve these conditions. However, the DIMENSION Power Supply QTD20.241 is provided with the appropriate features in the form of an enhanced input stage (Fig. 6). The DC/DC converter QTD20.241 is a modification of the QT20.241 with a permitted DC input voltage of 360...900VDC.

## Conclusion

PULS offers an extensive portfolio of safe DC/DC converters from 15W to 480W and take this issue very seriously. The safety of both man and machine should always be paramount. This is why appropriate protection measures play a crucial role in power supply units. Even reputable companies sometimes design their power supplies with attributes that cannot withstand a regulatory stress test. PULS power supplies are certified and have therefore been tested by an independent testing institution. This means that even with the approval of a complete system you are protected against any unpleasant surprises



6: DIMENSION QTD20.241, is especially suitable for the power supply of frequency inverters from the intermediate circuit voltage in the range of 360...900VDC.

### About PULS

PULS is the only company worldwide focused entirely on the development and production of DIN rail power supplies. We concentrate our engineering knowledge, resources and energy on one goal: To be the best in this technology. As a result of this focus, our product families DIMENSION, PIANO and MiniLine set standards in terms of efficiency, size and service lifetime.

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