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Hybrid UPS for High Current Load Capacity for Long-term buffering according to VDE-AR-N 4110

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Effective realization of high current loadable long-term buffering

Consumer with critical infrastructure like fire alarm systems, gas warning systems, position lights, network transfer stations etc. should use a DC voltage UPS system with a long term and secure power supply!

With such long-term buffering, it often occurs in practice that after a long discharge time of the battery with a very low load, a short-term high current is required at the end.

An already strongly aged or discharged battery could not deliver such a safe current and breaks down. A new „Hybrid UPS“ could remedy such a situation and will also deliver the required high current.

-*“In the system certificate is the concept of the self-consumption and auxiliary energy supply in the transfer station to be identified and assessed according to 6.3.3.*
If the supply for internal requirements is provided by converters, their connection is to be made in accordance with 6.3.3 evaluate.

If the auxiliary power is supplied by a battery system, it must be dimensioned in such a way that that all protection, secondary and auxiliary equipment for the operation of the transfer station including the counting and measuring devices can continue to be operated for at least 8 hours in the event of a mains voltage failure. Three complete switching sequences must be possible within this time. "

Source: VDE-AR-N 4110 11.4.21 internal and auxiliary energy supply transfer station

Batteries as endurance runner for long term buffering

Basically a lead acid battery is the right choice for long term buffering if the application stands for „Back-up“ and not for cyclical applications. If the load of the battery is constant during the buffer process the required capacity is easily calculable.

With long-term buffering, the lead battery is generally the means of choice as energy source, as long as it is pure backup processes and not a cyclical application. When the load on the battery is constant during the entire buffer period, the required capacity can easily be calculated. However this becomes problematic if an aging factor and possible on the batterie because of high or low temperatures must be taken into account. These factors have a major impact on the capacity of the batteries.

For example, with a base load of 1.5 A / 24 V, we need 2 blocks for 8 hours of buffer time, purely arithmetically 12 V / 12 Ah batteries each. If we assume an aging factor of the battery of 20%, there are 2 blocks of 12 volts / 17 Ah necessary to achieve the 8 hour buffer time. The aging of a lead battery is characterized by the reduction in capacity and increase of internal resistance (RI for short). Regular automatic Stress tests can ensure reliable functioning over long periods of time.

The most common batteries are by manufacturers according to EUROBATT (Association of European Manufacturers of Automotive and Industrial Batteries) with regard to their calendar lifespan. EUROBAT 5 stands for 5 years of use, EUROBAT 10 to 10 years use and EUROBAT 10+ for 10 - 12 years of use. With a corresponding charger with I / U characteristic, temperature-controlled charging and low ripple (to prevent the battery from heating up during charging or to keep trickle charge as low as possible), this service life can be achieved quite reliably.

Load jumps and temperatures as stress factors for batteries

It becomes problematic, however, when higher currents are required at least temporarily. This can be the case if e.g. switching operations, starting currents of a motor etc. are to be carried out via the accumulator.

The problem here is in particular the increase in internal resistance (RI). The RI is increased by aging or by discharge.

> Increasing in the RI through aging: The longer the service life increases, the greater the internal resistance of the battery. Over the years, this can reach three times the value of the new condition. At high temperatures it will this process accelerates.
>
> Increase of the RI by discharging: The deeper the battery is discharged during buffering, the more it is increased the internal resistance.

The aging processes accelerate considerably at higher temperatures. As a rule of thumb here it can be assumed that the calendar life of a battery, which is based on a Ambient temperature of approx. 20 ° C, halved for every 10 ° C increase in temperature. At low temperatures (well below 20 ° C) the speed of the internal chemical processes decreases significantly, so that the battery can neither deliver its full capacity nor particularly high discharge currents.

How can a reliable function be ensured over a long period of time?

There is of course the option of over dimensioning the calculated battery capacity. However, the exact oversizing factor is difficult to predict. Due to the temperature dependence factor 2 (30 ° C) or factor 4 (40 ° C) could be selected.

It would be conceivable to use a 40 Ah or even a 65 Ah battery instead of a 17 Ah battery. This does not control the problem of the low temperature ranges and the increase in the internal resistance due to "normal" aging. In addition, the acquisition costs and the space requirements increase without having to be absolutely certain whether the system is properly dimensioned. Usually when calculating the capacity, you calculate with an aging reserve of 20 - 25%,

Alternatively, it is also possible to carry out regular maintenance and tests. However, the more capacity one System, the more complex the discharge test with appropriate resistances and RI measurements place on the battery. This increases the expenditure of time and personnel costs. One solution to this problem is to use a UPS with an integrated RI measurement. In use of fire alarm systems, this is already mandatory according to EN 54-4. These special UPS devices regularly measure the RI of the connected system and report when a pre-set limit value has been exceeded.

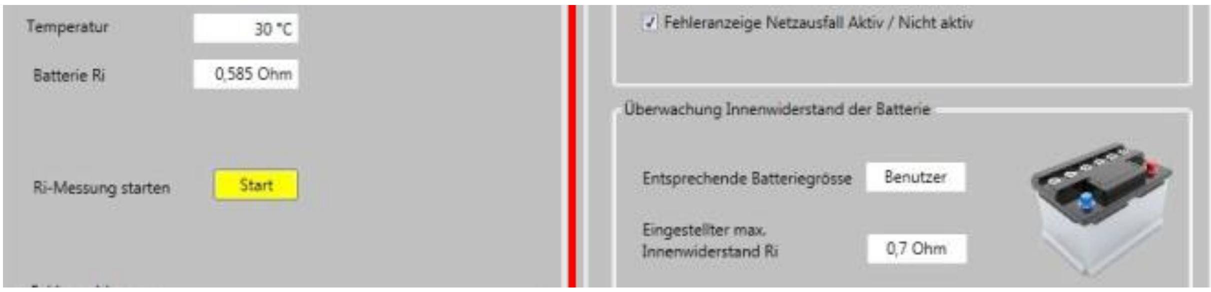

Diagram 1: Example of a measurement with an AKKU*TEC* with a setting of max. RI 700 mOhm and a measured value of 585 mOhm

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Here it is very reliably predicted when a battery must be replaced at the latest, to have the necessary security in the process.

<u>Hybrid USV as a solution</u>

For the problems described, J. Schneider Elektrotechnik GmbH has a special hybrid UPS developed. It ensures a very long use of the batteries and maximum reliability (without extreme high personnel costs for examination). The hybrid UPS is a combination of a battery Charger (AKKUTEC 2403) with battery monitoring (RI measurement and battery circuit test) and a DC UPS (C-TEC 2425 P) with ultra capacitors (UC for short). The two devices have been specially designed to work together to create a to ensure optimal supply of consumers.

The combination of the two devices shows its strengths in applications with the following critical situations:

- The application is already close to the End of the discharge.
- The batteries have already aged and the RI value has increased accordingly.
- Temperatures below 10 ° C prevail in the application area.
- A combination of several of the above.

Figure 2: Hybrid UPS J. Schneider Elektrotechnik GmbH

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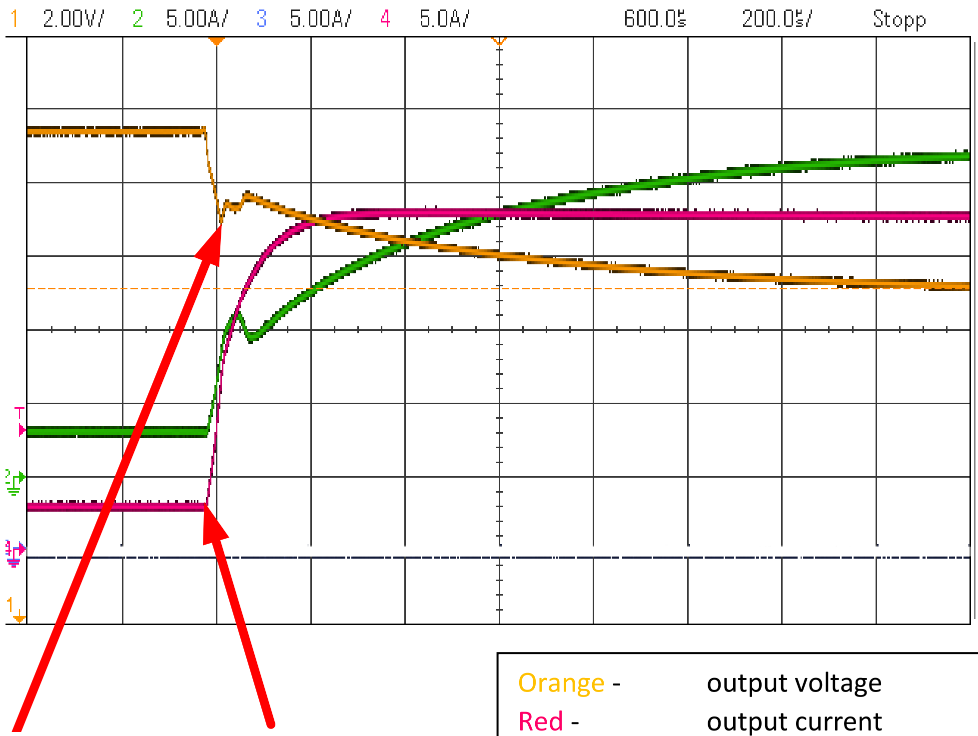
Hybrid USV in practice

Three different battery capacities (18 Ah, 24 Ah, 40 Ah) with a Base load of 3 A and an additional peak current of 20 A for 100 ms. During these exams, the following parameters are logged.

- Output voltage and output current of the hybrid UPS
- Battery output current
- Output current of the DC UPS with UCs

This test was carried out with fully charged and 80% discharged new batteries. Afterward the test was repeated with an aged battery. For comparison, the tests were carried out first with a battery-only UPS and then with the hybrid UPS carried out. Test example: heavily aged 18 Ah batteries discharged to 22.9 V DC.

Voltage drop in the event of a load change in a pure battery UPS



Orange -	output voltage
Red -	output current
Blue -	C-TEC output current
Green -	output current batteries

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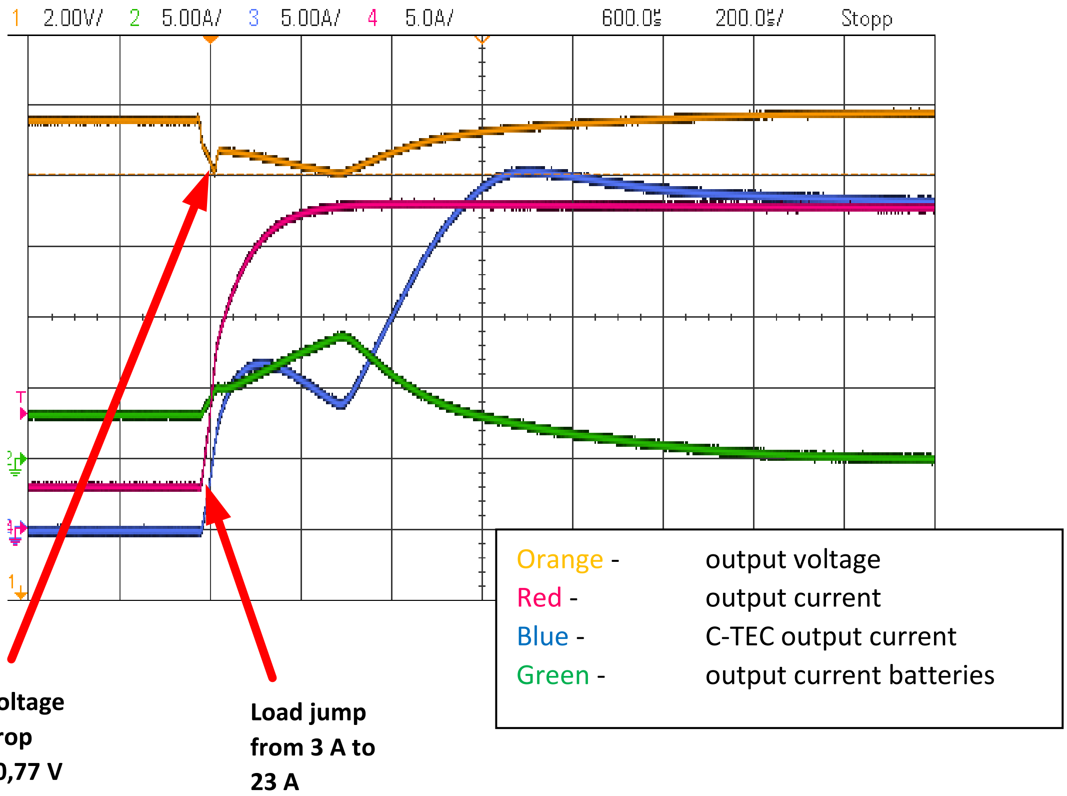
<u>Voltage drop in the event of a load change in a hybrid UPS</u>



Anhand der blauen (C-TEC) und grünen (Batterie) Kurve ist zu erkennen, dass die Ultrakondensatoren die Batterien entlasten und somit die Spannung nicht so stark einbricht. Dies ist bei allen Batteriezuständen (neu, gealtert, geladen oder zu 80“ entladen) der Fall allerdings in unterschiedlicher Ausprägung. Die Ergebnisse der gesamten Messreihe können bei J. Schneider Elektrotechnik angefordert werden.

The blue (C-TEC) and green (battery) curves show that the ultracapacitors relieve the batteries and thus the voltage does not drop as much. This applies to all battery states (new, aged, charged or 80 "discharged) but to varying degrees. The results of the entire series of measurements can be requested from J. Schneider Elektrotechnik

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Conclusion

The test shows that the batteries without the assistance of the C-TEC drop significantly towards the end of the service life.

When used according to VDE-AR-N-4110, several safe switching operations with inrush currents of up to 25 A can still be realised during or at the end of the 8-hour buffer time of the base load. If the **AKKU***TEC* reports an extreme increase in the RI, the batteries must be replaced.

What happens after the 8 hours of buffer time?

In principle, there are two options:

1. The system buffers until the batteries reach their deep discharge limit and then switches off the load (this should not be less than 1.8 V / cell for long-term discharges with a low load), otherwise the batteries are destroyed.

2. Alternatively, after the normatively required time of 8 hours, an automatic switch-off can be carried out via the AKKUTEC device. In this case, residual energy remains in the batteries. The hybrid UPS can be activated manually by means of a button; the residual energy of the batteries is sufficient to recharge the ultracapacitor module within a few seconds. Switching via the UPS is then possible again

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