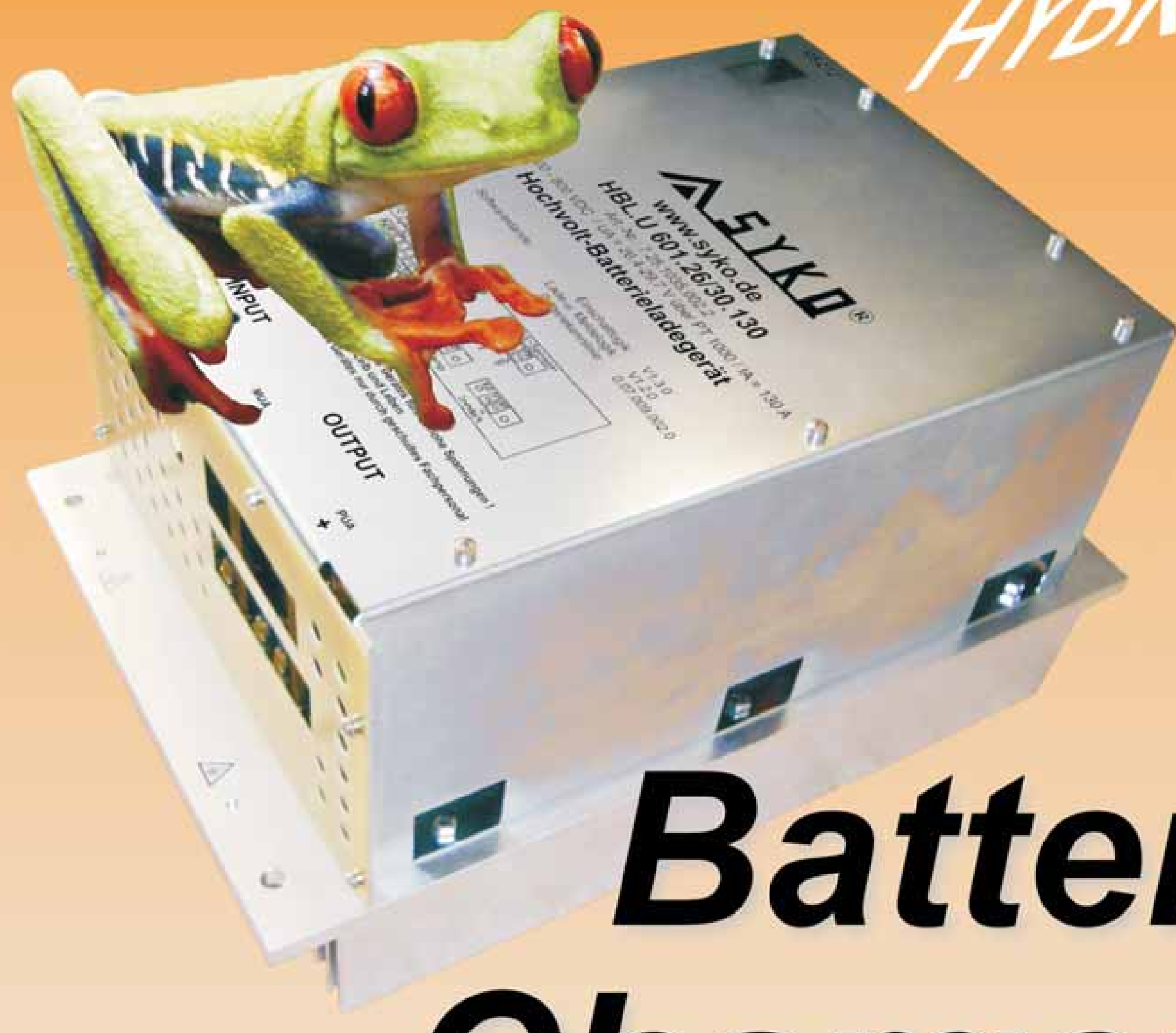
SYKO - Expert in Power Electronics

SYKO®

Gesellschaft für Leistungselektronik mbH

HYBRID



Battery Chargers

Railway applications, Special Technology
Hybrid Technology Vehicles

Network supply / Battery charging

1. In General:

Today intelligent management for battery charging is mandatory for the battery's live cycle consideration, particularly when the additional functional effort is very small. The use of temperature sensors is necessary to realise the changing set-point value for the charging end-voltage as function: U= f(T_{BAT}). SYKO defined the PT1000 series as standard temperature sensor. Currently the 1,5 KW (BLG) and 4,5 KW (HBL) standard battery chargers are offered for input voltages of 170-1050V DC with a dynamical input voltage range of 1:4. SYKO developed this modern power concept, which works with very high efficiencies, high functionality and lowest possible component stress. The battery chargers are available as on-board power supply with constant, regulated and short circuit proof output (VHO/HBV) or as intelligent battery charger (BLG/HBL). The following options are available:

- *Parallel connection for power and security redundant operation*
- *No de-coupling diodes necessary*
- *Parallel operation of battery charging and on-board network supply*
- *Adaptive set-point adjustment as function of battery current while splitting operation*
- *Output voltage as function of battery temperature*
- *Programmable battery curve as function over temperature*

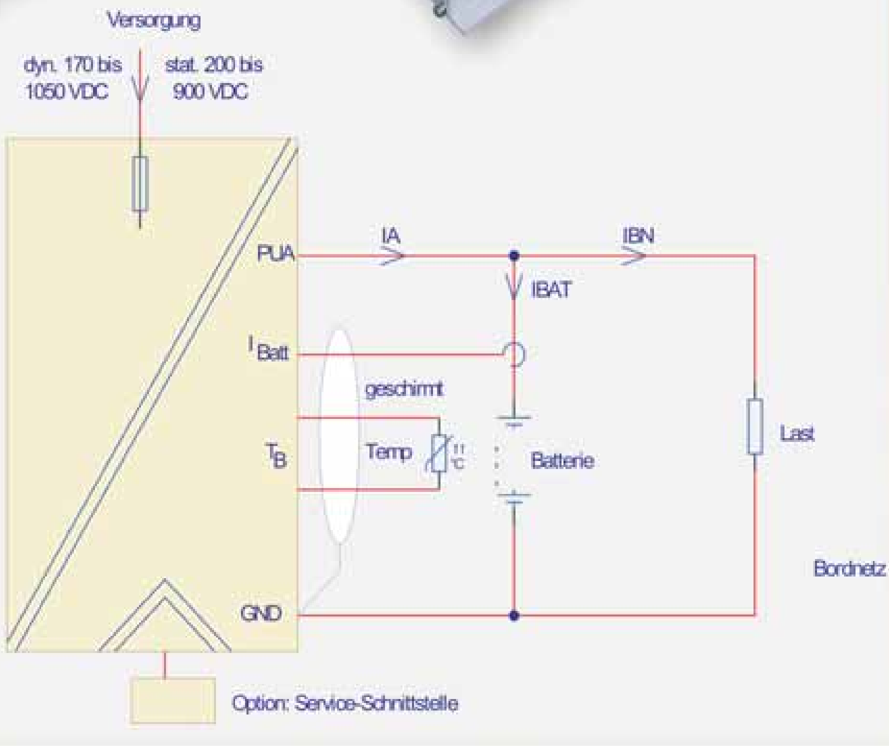
SYKO is able to realise custom demands according project specific requirements. One of the designed front-end solutions for nominal voltages of >1000V is based on the SYKO Patent Double Regenerator for 750V-traction line applications including transient strength of 1950V / 10ms. Further the front-end solutions for 2ph and 3ph AC-voltages including PFC have been defined as SYKO's sphere of competence. The power concept allows for the first time unproblematic battery charging >450V or high cap charging up to >600V (question of output diodes) even in the vehicles standstill mode with an input voltage range of >1:4.

2. Single device operation

Picture 1 shows the standard operation for fix voltage (blue) with optional (red) intelligent battery charging = f (T_{BAT}) and the parallel operation of intelligent battery charging and on-board network supply = f (U_{BAT}). Here the charging current I_{BAT} is constant and limited and counts as partial current of the output current I_A

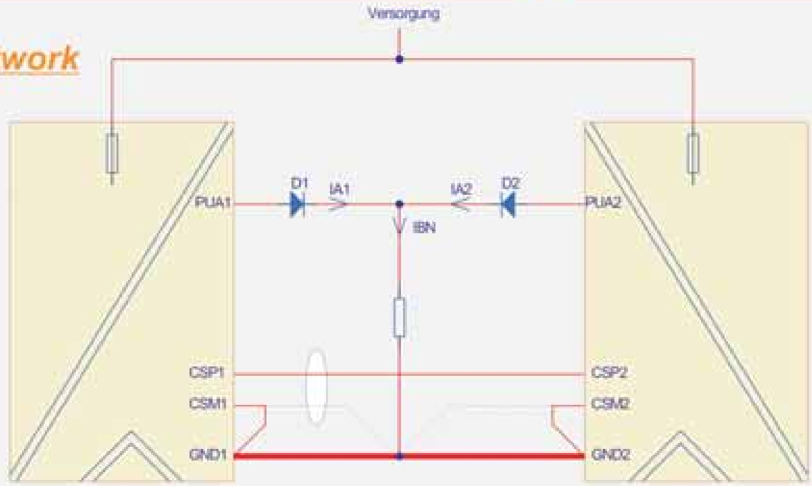
$$I_A = I_{BAT} + I_{BN}$$

In the case of parallel operation the battery can be seen as a time-variant Z-diode and the on-board voltage is equivalent to the battery's charging situation.



Parallel connection / Parallel operation

3. Parallel connection on-board network



a.) Power redundancy without D1/D2
b.) Savety redundancy with D1/D2

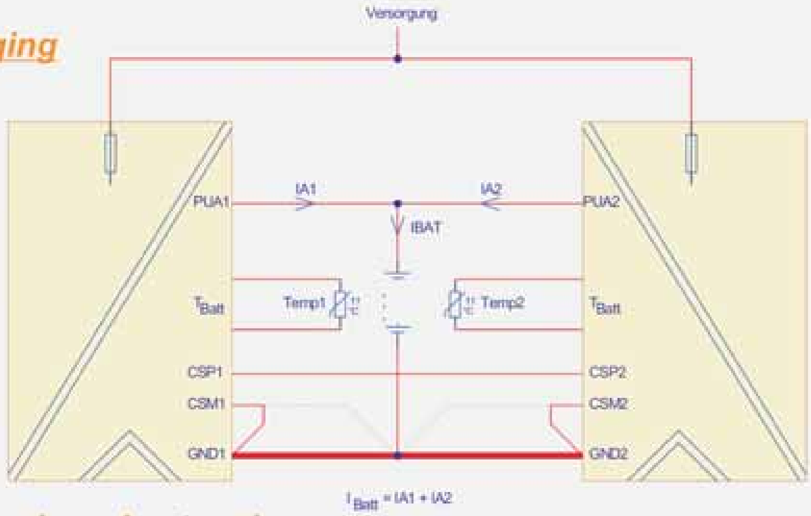
I_{BN} = IA1 + Ia2

3a.) Very easy parallel connection for power redundancy for double on-board network power by using Current-Sharing (CSP). TheCurrent Sharing regulates at unchanged output voltage the following output currents:

IA1 = Ia2

3b.) External de-coupling diodes (with good thermal connection) must be placed into output PUA1 and PUA2 when savety redundancy operation is needed. The resulting current I_{BNmax} = $IA1_{max}$ bzw. $Ia2_{max}$. While normal operation the current is: Ia1 = Ia2.

4. Parallel connection battery charging

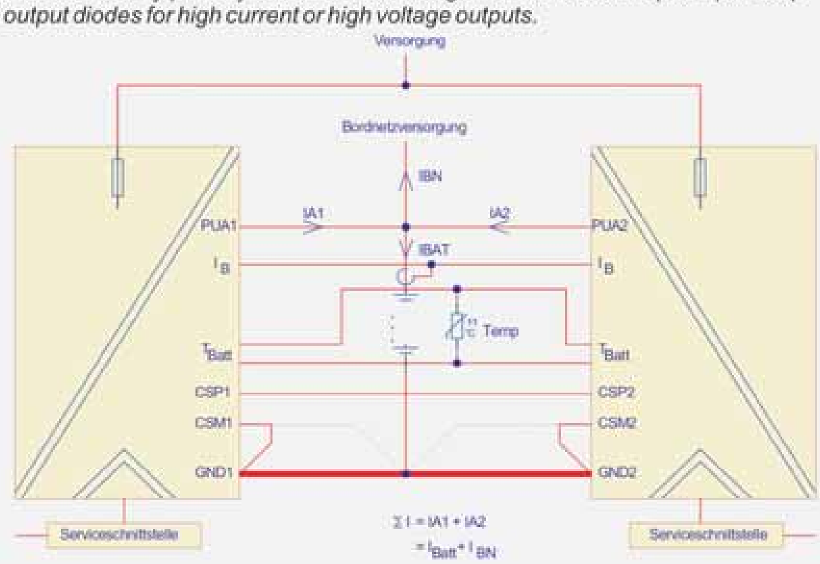


a.) For power redundancy
b.) For savety redundancy with D1/D2

To realise high requirements of functional battery managements the output voltage must be regulated/adjusted as a function of the battery's temperature. When each battery charger is equiped a temparature sensor PUA1/2 will be compensated that the offset inbetween both outputs is a minimum. The current will be regulated by Current-Sharing that the resulting current is: **IA1 = IA2**. The maximum battery charging current I_{BAT} must be adapted/limited to the battery's characteristic.

5. Parallel connection battery and on-board network

1. Specific transformer problems with Streuinduktivitäten are solved by primary sided current/voltage resonance of the push-pull-step and the fact that no Spannungsüberhöhung occur at the output diodes for high current or high voltage outputs.



2. Power management
Especially for the BLG series SYKO designed a power management including voltage-set-point, internal auxiliary power supply, Power-Sharing, current splitting, UA=f(TBAT) . With this device 3 battery charges (80A each) can work parallel. Power conduction is realised with massive current rails. With this system the regulated output voltages are also equalised and drive equal output currents to the according batter voltage with CSP. The reserve of current of each converter is available to supply the on-board network.

3. The battery chargers can be set up in a cascaded constellation (parallel connection) for more output power. Then the sum output current (Io1+Io2 +Ion)is higher than the battery's maximum allowed charging current (IBAT). This complex function requirement is realised with SYKO's Battery-Charging-Management:

- **The charging-end voltage is a function of the battery's temperature (T_{BAT})**
- **The on-board network voltage equates the battery voltage**
- **The output currents (of each charger) are [(I_{BAT} + I_{BN}) / n] for current into the battery with CSP**
- **The charging current I_{BAT} is limited over I_B**
- **The battery chargers are equipped with a floating service interface**

Flexible, Intelligent and Reliable

Topology:

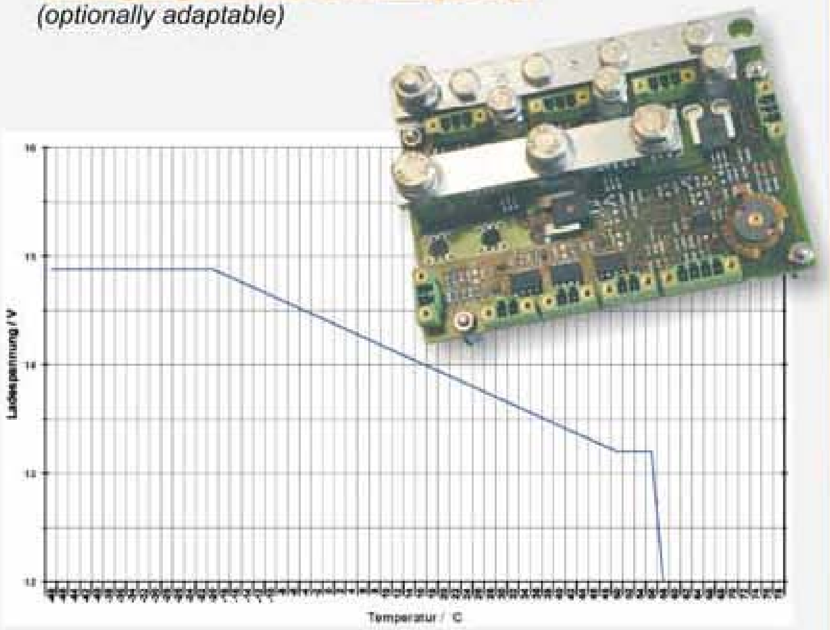
SYKO uses topology cascading, which allows the handling of a PCB linked high power solution with current and voltage cascading. The topology's power loss is distributed over the whole PCB area and the efficiency has been improved to 93 % typically. A total power limitation or current limitation is realized with sub-laid average-current-mode regulation circuit.

Intelligence:

Different battery charging curves can be programmed or used with RS232-interface and an optional available user interface. The charging voltage is set by the use of a PT1000 element, which detects the battery temperature (ring tongue style). Up to the charging end-voltage the maximum current is driven (splitting). The current will reduce when the charging end-voltage is reached. All auxiliary voltages are available before the power steps are activated. The auxiliary voltages are generated by an internal power supply and controlled primary sided as well as secondary sided. The monitoring and control functions are active even in critical operational situations and in the case of a short circuit.

Charging curve $U_{out} = f(T_{Bat})$:

(optionally adaptable)



Mounting situation:

The installation instructions must be observed to realise an optimal cooling situation (positioning / air stream distances). Heat transport to the outside of the converter is possible with the adaptable flange heat sink and the outside area and inside area are separated. Internal fans (optionally speed regulated) generate forced cooling to reduce remained hot spots (improve of MTBF).

Thermal limitation:

The heat sink's temperature is monitored and in the case of over temperature the converters switches inactive after a certain time. The internal temperature is monitored on the PCB and results the activating of redundant fans. In the case of the PCB's over temperature the power block switches off. An un-allowed temperature is signalled to the customer before switch off and the maximum output current is reduced (optionally). From a heat sink temperature of 60°C (70°C) upwards a defined de-rating is to observe.

Model over view: (Product line H)

Model	Ui / V (DC nom)	Version / Type	Power / kW (stat./dyn.)
VHO	220/450/600/750	On-board supply/fix voltage	1,5 / 1,7
ZHO	220/450/600/750	On-board supply/fix voltage	2,5 / 3,6
HBV	220/450/600/750	On-board supply/fix voltage	4,0 / 5,0
BLG	220/450/600/750	Battery charging / U=f(T)	1,5 / 1,7
ZLG	220/450/600/750	Battery charging / U=f(T)	2,5 / 3,6
HBL	220/450/600/750	Battery charging / U=f(T)	4,0 / 5,0

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