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Typical Specification for 74V OR 110V Battery Charger	
Nominal battery voltage	74V or 110V DC
Power Rating	18kW (4 modules) - limited only by space
Supply voltage	600V DC or 415V 3-phase AC 50Hz
Battery charging method	Fixed voltage float charging OR Optimum charging algorithm
Battery charging voltage	74V or 110V DC (adjustable in software)
Maximum output current	250A or 160A
Ripple voltage	less than 2%
Efficiency	Better than 90%
Charging modes	Constant Current, Constant Voltage, Trickle all charging modes include Battery Temperature Compensation
Startup load	Equal to steady state load
Overload	100% and power limited
Signal outputs at control plug	Programmable fault relays RS232 communication
Display	Indication of charger current, battery current, battery voltage, battery charge, battery temp.
Ambient temperature	-10°C to 55°C
Mounting location	Within vestibule or locker, 19" rackmountable
Physical protection	IP21 internally forced ventilated
Dimensions	510mm (W), 412mm (H), 484mm (D)
External connections	• 3-phase supply input • DC output • RS232 Optional military-style connections
Voltage surges; lightning	Differential mode 2.6kV$_p$ Common mode 1.3kV$_p$ for 100μsec Waveform 1.2/50μsec
Weight	80kg

Protective Features

- I x t overload protection
- Instantaneous over-current protection 150%
- Output short circuit protection
- Earth Fault
- Phase loss
- Over voltage
- Under voltage
- Over temperature heat sink
- RTD input facility
- Battery over temperature

Standards	
EN 50155	Electronic equipment used on rolling stock
IEC 1287-1	Power converters installed on board rolling stock
EN 50121-3-2	Electromagnetic Compatibility
IEC 61000-4-3	EMC standard
IEC 61373	Railway application rolling stock equipment: Shock and vibration testing
BRB/RIA-12	British Rail Standard for transients and surges
AS 3000	Wiring regulations

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Certified System
Quality
ISO 9001
SAI GLOBAL

AUSTRALASIAN RAILWAY ASSOCIATION INC
MEMBER

985-0005-01

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BATTERY CHARGERS

Input: 600V DC or 415V AC 3-phase
Output: Voltage and Current as battery charging requires

Battery Charging
Batteries used on rolling stock are either lead acid or nickel cadmium. Both types are available in sealed form so that water or gel does not need to be added. Batteries on diesel driven cars (DMUs) are used to start the engines and supply power for the switch gear and air conditioning on the car. On electric trains, batteries are used to power the pantograph gear to connect the train to the overhead wires and can also act as a backup power supply.

Train batteries are typically large and expensive and require special care when charging so they last longer. Consequently, charging these batteries is more complex than you may expect.

Basic Battery Charging Method - "Float Charging"
Most basic battery chargers use a method known as "Float Charging". A fixed charging voltage is set, higher than the open circuit voltage but slightly lower than the gassing voltage. In certain circumstances this can be satisfactory but generally it is not preferable because this does not give optimum performance of the batteries and reduces their effective life.

Optimum Battery Charging Algorithm
The optimum battery charging algorithm is summarised below. Keeping to this algorithm will extend the life of the batteries to the maximum possible. This applies to batteries in constant use as well as those kept in storage.

During the charging mode of operation the batteries should be charged according to the optimum charging profile shown in Figure 1.

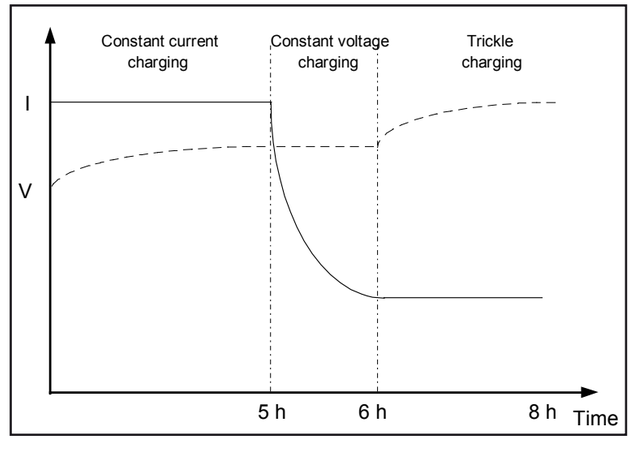

Figure 1: Optimum Charging Profile

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There are four modes of operation during optimum charging.

1. ***Constant Current Charging*** - During the first period of charging (which would typically last 5 hours) the batteries are charged at a constant current of **15.5%** of their Amp-hour rating. The battery voltage increases and at the end of this cycle the batteries reach their gassing voltage. At this point the battery charging mode switches to constant voltage.

2. ***Constant Voltage Charging*** - The second period of charging (typically lasting an hour) commences when the DC link voltage reaches **2.4 volts/cell**, and the batteries are charged at a constant voltage. The current drops away exponentially. When the charging current reduces to the trickle charge level, the battery charging mode switches to trickle charge.

3. ***Trickle Charging*** - When the current drops to **3.5%** of the Amp-hour rating, the batteries are once again charged at a constant current, but at the reduced charging rate.

4. ***Battery Charged*** - When the rate of change of DC link voltage drops below **1%** of the nominal voltage per half-hour, the batteries are fully charged and charging is complete.

The optimum charging profile is that specified by British Standards, IEC Standards and Australian Standards, AS2402.

Battery Equalising
Over time, depending on how the battery is used, sulphate crystals can accumulate within the battery and harden to form insulation. This is called Sulfation. Such sulphur accumulation reduces the effective surface area of the cell plates and thus reduces battery charge capacity and battery life. Another condition known as *stratification* is where different concentrations of acid form layers within the battery liquid leading to uneven charging and reduced battery life.
Battery Equalising is a method of charging a battery at a higher voltage, producing gassing, but at a limited current. This function dissolves much of the accumulated sulphur and mixes the battery solution thus extending battery life. Gel type batteries do not require equalising.

Temperature Considerations
The temperature of a battery has an effect on the amount of charge a battery accepts and the rate at which it will accept the charge. Advanced battery charging systems measure the battery temperature and adjust charging voltage and current accordingly.

SCHAFFLER Battery Chargers

SCHAFFLER Battery Chargers are designed taking into account the specific circumstances effecting battery charging in combination with the rugged requirements of railways. These factors include:

- Type of battery
- Typical and peak battery usage
- Required charging method
- Voltage, Current and Power constraints
- EMI and audible noise
- Shock and vibration
- Fault protection and redundancy

All locomotives are different and have specific requirements, however the basic principles of battery charging and care remain. SCHAFFLER have great experience in battery charger design. SCHAFFLER Battery Chargers protect investment in battery systems by maximising battery life.

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Typical Specification for 24V Battery Charger	
Nominal battery voltage	24V DC
Power Rating	6kW or 2 x 6kW with RS485 communication between master and slave (optional)
Supply voltage	600V DC or 415V 3-phase AC
Battery charging method	Fixed voltage float charging OR Optimum charging algorithm
Battery charging voltage	27.6V DC (adjustable in software)
Maximum output current	220A OR 500A using 2 x 6kW chargers
Battery charging current	Controlled to 60A in constant current mode, remainder of current available to standing load
Ripple voltage maximum	< 0.5V peak to peak at 6kHz Output DC filter will be provided
Efficiency	Better than 90%
Active circuit	No connection to earth
Startup load	Equal to steady state load
Overload	I^2t set at 150% full load current
Signal outputs at control plug	0-10V DC proportional to charging voltage 0-10V DC proportional to charging current
LCD display	Visible through a window without removing the battery charger cover LED indicating full status of the inverter LED indication of charging current LED indication of charging voltage
Ambient temperature	-10°C to 60°C
Mounting location	Within vestibule, optional IP54
Physical protection	IP21 internally forced ventilated
Dimensions	330mm (W), 570mm (H), 265mm (D) Battery charger will be supplied with an integral mounting tray with slotted holes to fit into the mounting cavity
External connections	Two military-style plugs including mating cable plugs • 3-phase supply input • 24V DC output and Data Control • Control connections
Voltage surges; lightning	Differential mode 2.6kV$_p$ Common mode 1.3kV$_p$ for 100μsec Waveform 1.2/50μsec

Protective Features

- I^2t overload protection
- Instantaneous over-current protection 150%
- Output short circuit protection
- Earth Fault
- Over voltage
- Under voltage
- Over temperature heat sink
- RTD input facility
- Battery over temperature
- Phase loss

External Communication

The battery charger has two sets of normally open contacts (potential free) for use by the Train Management System. One represents "battery charger failure" and the second represents "battery over temperature".
In addition two 0-10V signals representing battery voltage and current are available at the control plug for data logging.

Xplorer/Endeavour Battery Chargers

Xplorer/Endeavor trains are DMUs that run in the outer metropolitan areas of Sydney, NSW.
The battery chargers on these trains are of the basic charging type. 24V batteries are charged at a constant 27.6V whilst the current is measured. When the charging current reduces to a preprogrammed level then charging ceases.

VLocity Battery Chargers

The VLocity trains are DMUs that run in the outer metropolitan and country areas of Melbourne, VIC. The battery chargers on these trains follow the optimum charging algorithm and output 250Amps.

Hunter Battery Chargers

The Hunter trains are DMUs that run in the Hunter Valley in NSW. The battery chargers on these trains follow the optimum charging algorithm and output 500Amps. These chargers are installed as a master/slave pair and provide 100% redundancy.