

APPLICATION NOTE

Lead Acid Battery Charging

Introduction

Lead acid battery chemistry has unique charging requirements. Correct selection of battery charger can increase the operational battery life time. This guide contains basic information about lead acid battery, charging method and brings overview of Bel Power Solutions charging solutions.

LEAD ACID BATTERY

Lead acid deep-cycle batteries are the most popular used batteries where large amounts of energy are stored and low cost is preferable than weight or physical size. Typical applications include backup power for alarm or telephone systems, UPS systems. The deep cycle batteries have thick plates for improved cycling abilities and for providing continuous power than starter battery which is designed for cranking engines with momentary high power burst.

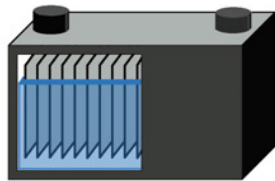


Figure 1. Starter Battery

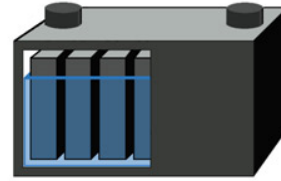


Figure 2. Deep cycle battery

Charging Methods

Charging methods are dependent on battery application which can be classified into main power battery usage and stand-by/backup power battery usage.

Main power – cycle use is to use the battery by repeated charging and discharging in turn.

Charging cycle Figure 3:

T0 - T1 - the charger supply small current typically C/100 (charge rate) to the battery until the battery voltage reaches predetermined threshold level (V_{chgenb}). The purpose of this period is to prevent before continuously pumping huge current into a damaged battery. This period may be skipped or permanently disabled when battery voltage level is higher than predetermined threshold level.

T1- T2 - the charger supplies constant current (I_{bulk}) into the battery. This current is applying until battery voltage rise up above 95% of max. overcharge voltage.

T2-T4 - the charger tries to regulate battery voltage to constant voltage during overcharge state. When charger enters to overcharge state, the constant current control is dominant and continues to feed battery. As battery voltage rises up to max. overcharge voltage, the charger switch regulation from constant current to constant voltage control (T3) .

T4 and further – the charge switch to float charge (V_{float}) period when charging current falls below preset threshold level (I_{oct}). While in the float state, the charger can supply I_{bulk} current to a load and battery. The charger remains in float period until battery voltage falls (discharge).

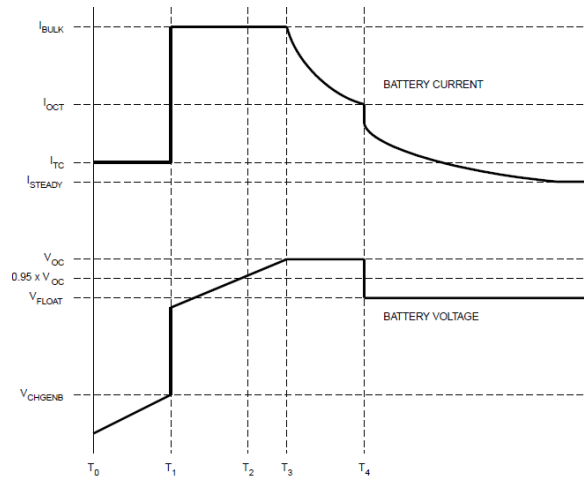


Figure 3. Charging Cycle Main power cycle use

Stand-by / Back-up use – is to maintain the battery system at all times so that it can supply power to the load in case the input is missing (power failure). There are two methods of charging:

Trickle Charge Method

The battery is disconnected from the load and constantly charged with a small current (self-discharge compensation). In case when input power failed, battery is connected to the load by power detector relay. When input power is restored back, the power detector relay disconnects battery. In this case, battery presents emergency power equipment. This method requires to use separately output, primary as source for load and secondary as battery charger. Primary output is set to nominal constant voltage power (nearby nominal current) and secondary output is set for battery charging level.

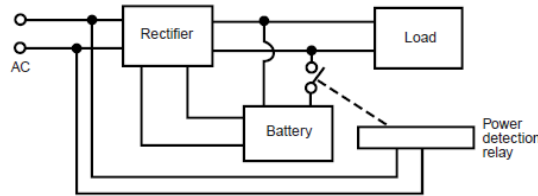


Figure 4. Trickle Charge Method

Float Charge Method

The battery is permanently connected to the load in parallel with rectifier (charger) which should supply constant voltage and current too. In float system, capacity of rectifier should be more than sufficient against the load. Usually is set at the sum of nominal load current plus maximum battery current.

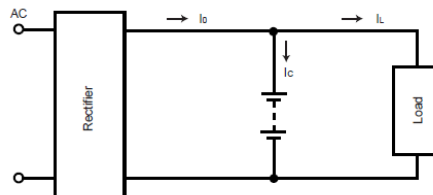


Figure 5. Float Charge Method

However battery in both of this method is only rarely deeply discharge, simply constant voltage and constant current charging method is ideal for this application. These chargers are generally very gentle to batteries whilst the chargers are used as the designer intended. A review of charging cycle can explain why improper use of one of these chargers can be a cause of battery damaged.

Charging cycle Figure 3:

The discharged batteries are charged at the maximum current that the charger can supply. The charger remains in this constant current mode (bulk) until the battery voltage reaches floating sets voltage (standardly 13.8 V for 12 V battery at room temperature). At this point, the charger switches to constant voltage mode (float). The charger switches from bulk to float mode based only on the battery terminal level.

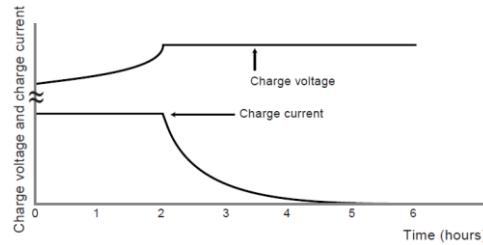


Figure 6. Charging Cycle back up use

Charging Voltage Level

The correct setting of the charge voltage is critical and ranges from 2.20 to 2.45 V per cell. Setting the voltage threshold is a compromise. Some lead acid batteries are used in a standby condition in which they are rarely cycled, but kept constantly on charge. These batteries can be very long lived if they are charged at a float voltage of 2.20 to 2.30 volts/cell (at 25 degrees C) (13.2 V to 13.8 V for a 12 V battery). This low voltage is to prevent the battery from losing water during long float charging. Those batteries that are used in deep discharge cycling mode can be charged up to 2.45 volts/cell (14.7 V for a 12 V battery) to get the highest charge rate, as long as the voltage is dropped to the float voltage when the charge is complete.

Battery Charge Rate

The maximum battery charging rate is often specified by manufacturer as C/5 where C refers to the Ah rating of the battery. In many applications there is not needed to recharge battery quickly and smaller charger may be used to reduce size of charger and reduce heat of battery which increasing battery life time. Standardly recommendation for Stand-by/Back-up use is C/10 charging rate.

Temperature Compensation

The charge voltage should be compensated to the ambient temperature near the battery or battery temperature. Main reasons for the temperature compensation is to prevent thermal runaway of the battery when is used in high temperature or batteries are preheated by charging current.

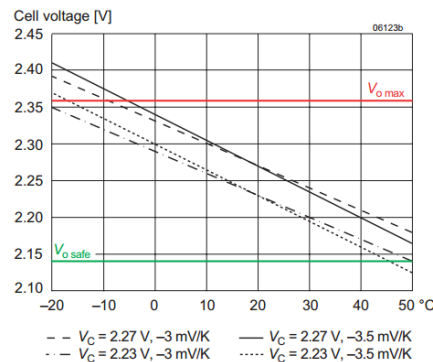


Figure 7. Temperature compensation of charge voltage

BEL POWER SOLUTIONS CHARGERS

Din Rail Chargers

Bel Power Solutions offers two types of standalone bespoke battery charging solutions for lead acid batteries. Din Rail and rugged cassette products as shown below.



Figure 8. A, O-Series B, W-Series C, X-Series

Vbat	Charger Model	I _{nom} [A]	Efficiency [%]	Case type	Input Voltage
12	LOK4140-2RLD	3,6	82	O	85-264Vac (47-63Hz), 90-35Vdc (W,X case), 90-250Vdc (O case)
	LWR1140-6EM1	7,5	83	W	
	LWN1140-6EM1	14	85	W	
24	LOK4240-2RLD	1,8	82	O	
	LWR1240-6EM1	4,2	86	W	
	LWN1240-6EM1	8,4	85	W	
	LXR1240-6M1	12,6	87	X	
	LXN1240-6M1	16,8	87	X	
36	LWR1840-6EM1	2,8	86	W	
	LWN1840-6EM1	5,6	86	W	
	LXR1840-6M1	8,4	87	X	
	LXN1840-6M1	11,2	87	X	
48	LOK4740-2RLD	0,9	82	O	
	LWR1740-6EM1	2,1	86	W	
	LWN1740-6EM1	4,2	87	W	
	LXR1740-6M1	6,3	87	X	
	LXN1740-6M1	8,4	87	X	

Table 1. Din Rail chargers

Rugged Cassette Chargers

The MELCHER brand of rugged cassettes provide railway and transportation power supply and battery charger. Available in power range 50 W to 500 W.

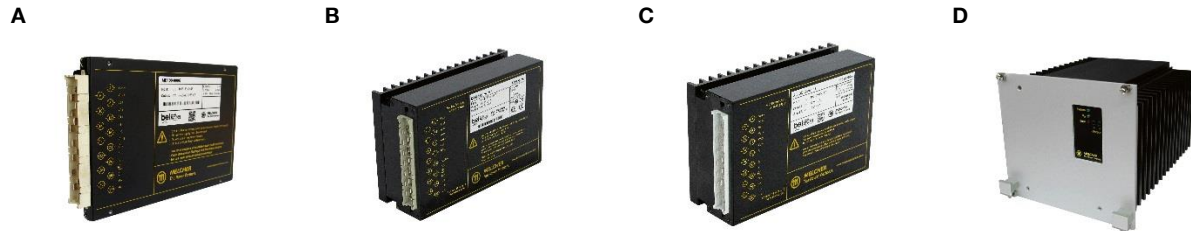


Figure 9. A, M-Series B, S-Series C, L-Series D, T-Series

Vbat	Charger Model	I _{nom} [A]	Efficiency [%]	Case type	Input Voltage
12	E/LM1781-9R	3,6	79	M	See datasheet for detailed information (L option 85-264Vac 47-63Hz, 88-373Vdc)
	D/LS1740-9ER	7,5	-	S	
	D/LK1740-9ER	10	83	K	
	LK4740-7R	10	84	K	
24	E/LM1782-9R	1,8	81	M	
	D/LS2740-9ER	3,6	-	S	
	D/LK2740-9ER	5	83	K	
	LK5740-7R	5,4	83	K	
	LKP5740-7R	9	86	K	
36	U/LT1240-7Z	14,4	91	T	
	E/LM1783-9R	1,2	82	M	
48	LT1840-7Z	11	91	T	
	E/LM1784-9R	0,9	81	M	
	D/LS2740-9ER	1,8	-	S	
	D/LK2740-9ER	2,5	83	K	
	LK5740-7R	2,7	83	K	
	LKP5740-7R	4,5	86	K	
60	U/LT1740-7Z	10	92	T	
	E/LM1785-9R	0,72	81	M	

Table 2. Rugged cassette chargers

Temperature Sensor

Bel Power Solutions offers a wide range of battery charger systems consisting of adapted power supplies and appropriate temperature sensors. The (lead-acid) batteries are charged according to the battery temperature and the properties of the battery cells. When the battery is fully charged, it is maintained at the float charge voltage, which represents the optimum point for maximum available energy and optimum life expectancy of the battery. It is essential to place the sensor as close to the battery as possible thus sensing the battery temperature.

Different models of battery sensors are available depending on the battery specifications. Table 3 gives an overview of available sensors.

Battery voltage nom.[V]	Sensor type	Cell voltage [V]	Cell temp. coefficient [mV/K]	Cable length [m]
12	S-KSMH12-2.27-30-2	2.27	-3.0	2
24	S-KSMH24-2.27-30-2	2.27	-3.0	2
24	S-KSMH24-2.27-35-2	2.27	-3.5	2
24	S-KSMH24-2.31-35-0	2.31	-3.5	4.5
24	S-KSMH24-2.31-35-2	2.31	-3.5	2
24	S-KSMH24-2.35-35-2	2.35	-3.5	2
48	S-KSMH48-2.27-30-2	2.27	-3.0	2
48	S-KSMH48-2-27-35-2	2.27	-3.5	2

Table 3. Temperature sensors models

T Series battery chargers exhibit a cell voltage selector switch to set the required floating charge voltage directly at the converter. A special temperature sensor T matches to the T Series. All details are provided in the T Series data sheet at Bel Power Solutions web site: belpowersolutions.com.

The internal component limits the reverse charge current flowing into the output capacitors, when the converter is plugged into a battery-buffered bus. Should however the converter already be connected, when the battery is switched to the bus, the resulting charge current will not be limited. To avoid having the component blow or a possible arc across the circuit breaker, the battery charger should be powered by the mains prior to connecting the battery. With O-Ring diodes, no reverse charge current flows from the power bus into the output capacitors.

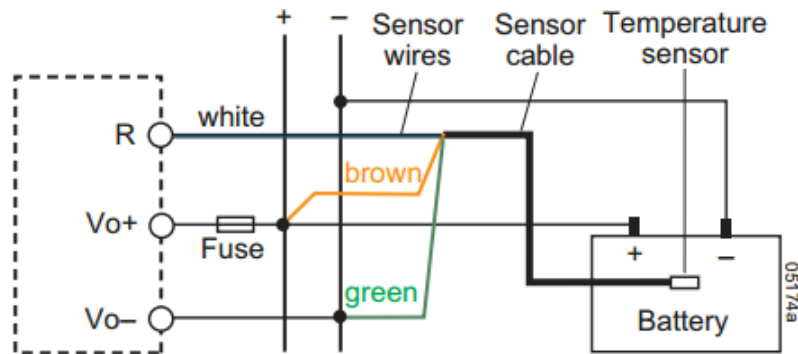


Figure 10. Connection of a sensor to the standard R input

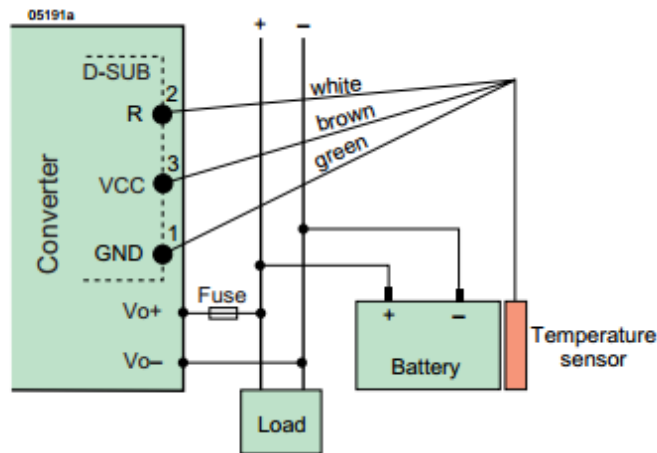


Figure 11. Connection of a sensor for din Rail

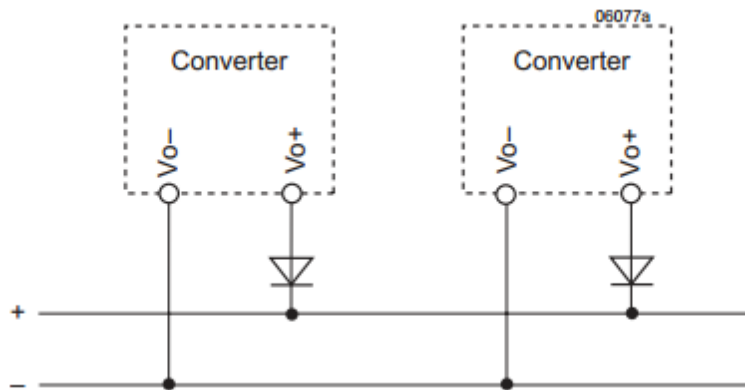


Figure 12. Redundant parallel connection