

# SMALL SECONDARY BATTERIES

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## Abstract

The fast growing business of portable electronics, telecommunication, wireless devices brings always higher requirements for batteries. Higher gravimetric and volumetric energy densities are required as well as higher power performance. Besides the energy density and the power performance a long life time and high safety parameters are essential including small, reliable and easy to operate charger with minimal charge duration. Development of small secondary batteries has had significant influence to portable electronics, telecommunication and wireless devices industry.

This paper concentrates on small secondary batteries, particularly on small consumer size batteries. It provides an information about the main principle of the most common small secondary batteries and their typical properties. A special consideration is paid to high power and to photovoltaic applications. An optimal balance of capacity and power performance is discussed. The paper contains interesting results from long lasting cycle life measurements and provides important hints for small secondary batteries applications.

In the first part the basic principles of small secondary batteries are mentioned. The most common small secondary batteries are NiCd and NiMH, the description also includes conventional lead-acid battery and Li-ion/polymer batteries. Lead-acid batteries are relatively cheap, they have high cell voltage and good power performance, normally they are not preferable as small batteries due to low volumetric and gravimetric energy densities, an unavoidable gassing and an electrolyte concentration change at cycling. Despite the drawbacks small lead-acid batteries still play some role in certain market segments like electric mowers, electric bikes, some toys, UPS and certain telecommunication applications. Lead-acid batteries are also produced in small subC size, e.g. Hawker Cyclon cells or Boulder's TMF cells, these cells have very high power performance. Li-ion/polymer batteries are the advanced batteries with high volumetric and gravimetric energy density and high cell voltage, their drawbacks are a high cost, a safety risk, and a requirement for a special charging equipment. In a case of Li-ion/polymer battery consisting of a few cells, single cells monitoring and control must be used.

In the second part the issue of power performance requirement is discussed particularly in the relation to NiMH and NiCd batteries. Tests at different NiMH batteries clearly indicated lower cycle life at higher cycling rate. Measured results also indicated that an increase of NiMH batteries capacity does not bring an increase of the power performance, however an increased nominal capacity sometimes brings some cycle life reduction, see Fig.1. Results on the Fig. 1 represents discharge capacity development at a high rate cycling (charge & discharge rate: 2A) at the room temperature measured at NiMH batteries of different nominal capacities produced by the same manufacturer. The Fig. 2 represents cumulative Ah throughput at the high rate cycled NiMH batteries to 88% of the initial capacity limit. Thus a serious consideration of a battery type, a power requirement and a capacity is necessary for an balanced and optimal operation.

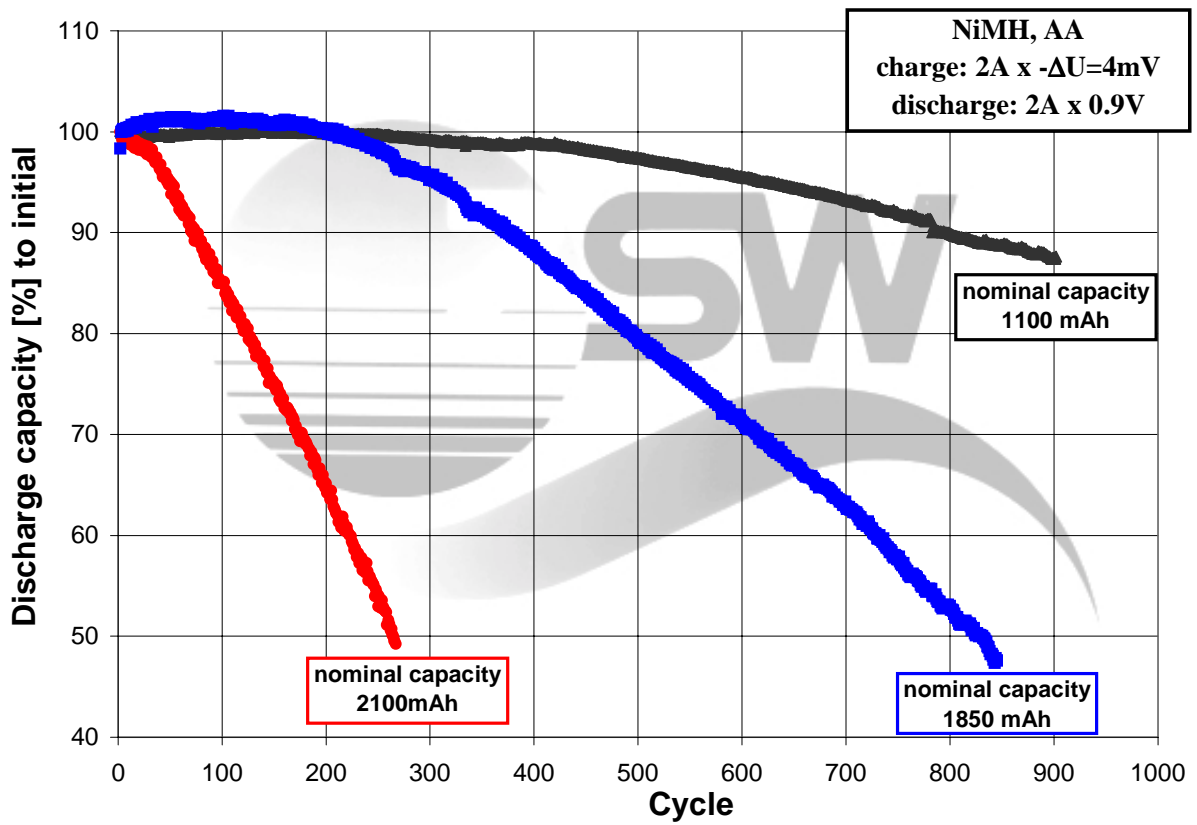
Batteries' temperature at cycling is known parameter that influences the cycle life. Measured cycle life at the room temperature and at 40°C constant ambient temperature environment proved more then three times longer cycle life at the room temperature in comparison with 40°C ambient temperature. Self-discharge parameters are important for low power applications and for back-up low power sources; in this connection some properties and applications of RAM cells are discussed. Measured self-discharge parameters are presented. Some overcharge and undercharge effects on the batteries performance were measured and results are discussed. An overcharging tests were performed on different NiMH batteries at 40°C constant ambient temperature, the batteries were overcharged by a constant charge rate of 0.1C for five months. Regular capacity check up in two weeks frequency did not indicate any decay of capacity measured at medium discharge rate. The following cycle life test after the overcharge was performed at the room temperature and at a high rate cycling (1C rate), the cycle life was measured higher then 1000 cycles. A long term constant overcharge even at higher battery temperature has not a strong effect to the battery cycle life

due to a high efficient oxygen cycle. However the standard cyclic operation at higher temperature had significant influence to the cycle life. Tests with overdischarge were done and results are discussed in this paper, cycling with 10% overdischarge resulted in half cycle life.

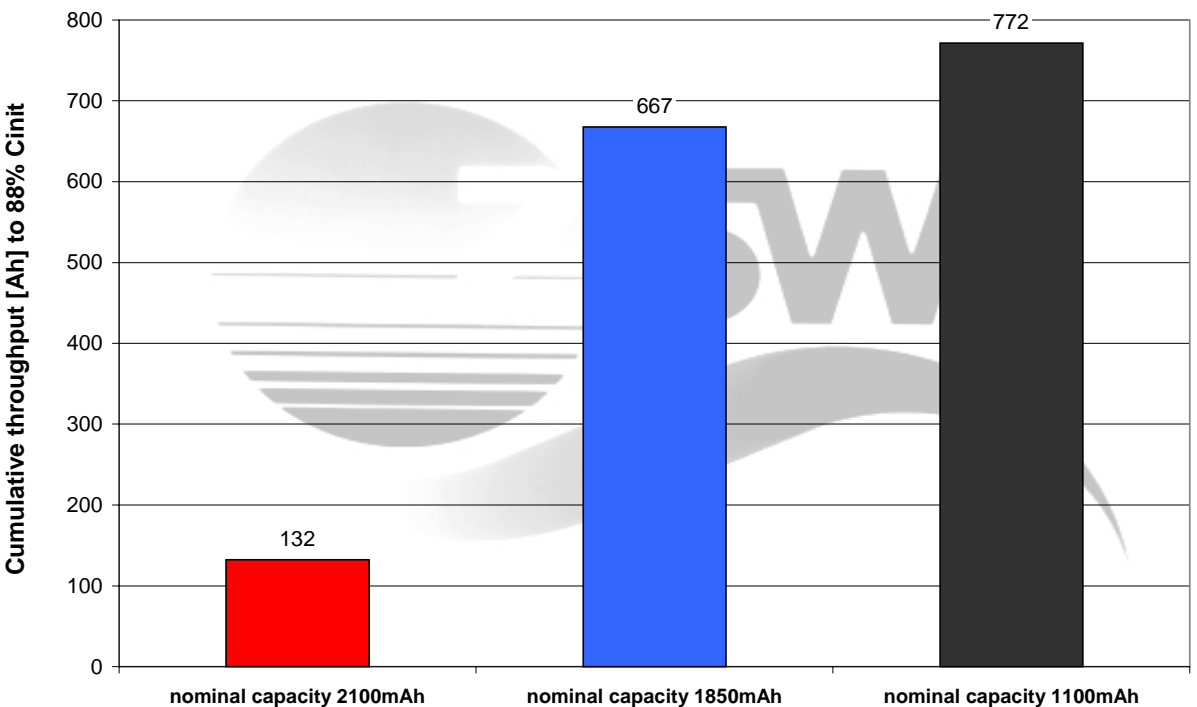
In this third part of the paper application of small batteries in PV systems is discussed. A specific requirements and conditions for batteries in solar applications are identified and appropriate test procedures are described. Despite a very high efficiency of Li-ion batteries these batteries indicated relative short life in solar application tests in comparison with lead acid batteries. Solar tests summary brings recommendation for optimal battery selection.

Results of long time cycle life tests are summarized and different test procedures are commented. This part brings description of the most typical degradation mechanisms. Some practical hints for small battery testing, optimal battery selection and operation are provided.

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**Fig.1.** Discharge capacity development of different nominal capacity NiMH batteries produced by the same manufacturer at high rate cycling in the room temperature.



**Fig.2.** Cumulative Ah throughput at the high rate cycled NiMH batteries to 88% of the initial capacity limit.