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The TLM Battery – A New High Power Primary Battery

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Introduction

Electronic systems are gaining wider influence in the automotive industry. Under the name E-call, an emergency call system is developped for passenger cars. Former domains of mechanical systems like the car latch are being conquered by electronics. These systems need to continue to operate even when the car battery is disconnected or damaged. The introduction of such advanced systems has been delayed because an emergency battery was not available or too expensive. This gap is now closed by the new TLM-battery.

Performance data

The new TLM-battery is small and light, delivers a high current and operates in a wide temperature range. The performance data are summarized in table 1.

Three cells in series comprise a compact, light battery that is compatible with the 12-Volt car battery.

Operating voltage	4.1 V ... 3 V
Available Pulse Capacity	550 mAh
Max. Cont. Discharge Current	5 A
Maximum Pulse Current	15 A
Operating Temperature	-40 °C ... +85 °C
Self Discharge	5 % (first year)
	2 % (subsequent years)
Storage Capability (20 % loss)	10 years
Diameter	15 mm
Length	50 mm
Weight	20 g

Table 1
Performance data, new TLM-Battery of type TLM-1550/HP

Design and materials

The electrode materials of the new TLM-battery consist of lithium intercalation compounds. This means that the anode consists of graphitic carbon, capable of accommodating (intercalating) lithium ions in its crystal lattice. The cathode consists of metal oxides, that can also accommodate lithium ions. The electrolyte is an organic solution. The battery is not pressurized. Its ingredients are not hazardous according to the European RoHS and battery directives.

The battery is not rechargeable. The electrodes are spirally wound, the housing is hermetically sealed by a glass-to-metal seal and LASER welding of the cover.

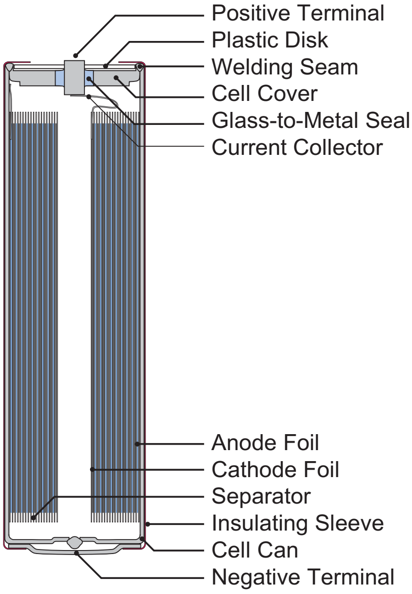

Fig. 1
Cross section view of a cell of type TLM-1550/HP

Electrical performance

Figure 2 shows discharge curves at room temperature and with 3 different current levels of 0.1 A, 2 A and 5 A. Even with a load of 5 A, the average discharge voltage exceeds 3 Volts and the capacity to 2.75 Volts exceeds 450 mAh

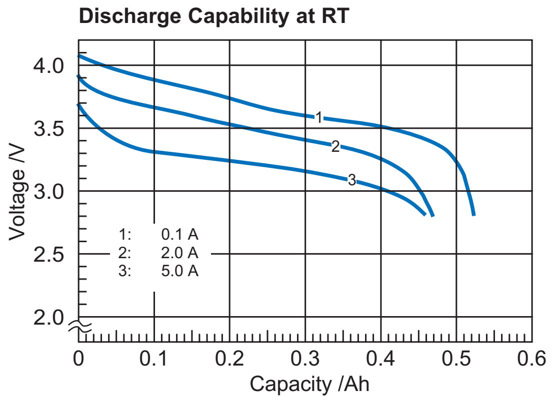

Fig. 2
Discharge curves of TLM-1550/HP at room temperature.

Figure 3 shows a pulse discharge with 15 A pulses, each being 1 s long and occurring at a duty cycle of 1 : 10. The battery yields a capacity of 480 mAh down to 2 Volts.

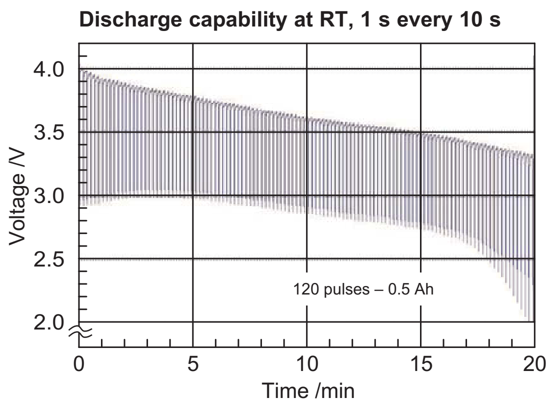

Fig. 3
Pulse discharge of TLM-1550/HP with 15 A @ 25 °C

Figure 4 explains the temperature behaviour of the new TLM-battery. It shows 5 discharge curves at 1 A continuous current over a temperature range from -40 °C to +72 °C. At -20 °C, the battery delivers 350 mAh above 3 Volts and exhibits no voltage delay. This proves that the TLM-battery outperforms any other battery system. The curves at -30 °C and -40 °C show a slight voltage increase during discharge. This increase is due to the self heating effect caused by ohmic heat loss

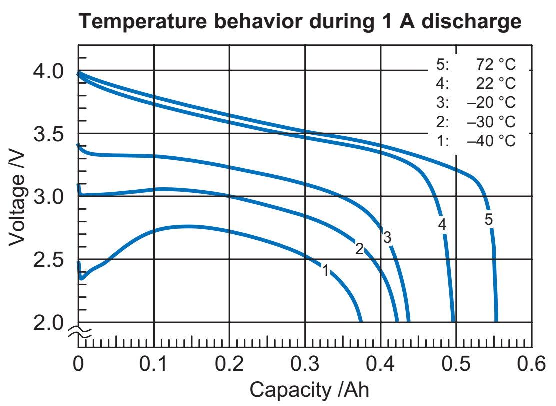

Fig. 4
Discharge curves of TLM-1550/HP at 1 A and temperatures between -40 °C and +72 °C.

Comparison to other lithium batteries available on the market

In order to better understand the performance of the new TLM-battery, a comparison study was conducted with lithium batteries of type CR123A available on the market (size 2/3 A, lithium manganese dioxide system). This type requires approximately the same space. With a discharge current of 2 A, the TLM battery has clearly a higher voltage level, while the capacity is almost equal (see figure 5)

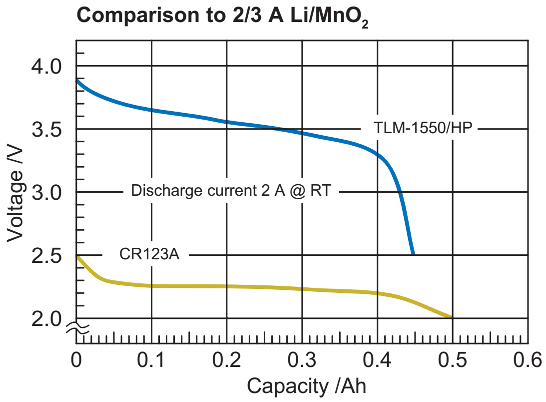

Fig. 5
Comparison of TLM-1550/HP with CR123A:
Discharge at a current of 2 A and at room temperature.

At low temperatures, the advantage of the TLM battery becomes even more evident. Figure 6 shows discharge curves at -20 °C with a current of 1 A. Here the TLM battery still delivers approximately 75 % of its nominal capacity while the compared battery delivers only 2 % of its nominal capacity, which is almost nothing.

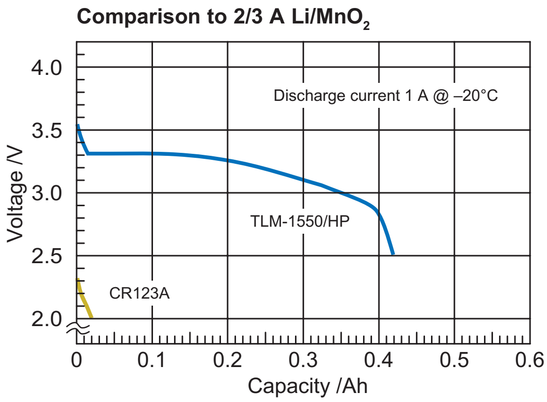

Fig. 6
Comparison of TLM-1550/HP with CR123A:
Discharge at a current of 2 A and at –20 °C.

Self discharge

One of the most important properties of the new TLM battery is its long storage capability and low self discharge. In order to investigate this behaviour, the open circuit voltage was observed over a period of almost 2 years, both at room temperature and at +72 °C. The resulting curves are compared to a discharge curve (“titration curve”) obtained with a discharge current that is very small compared to the current capability of the battery but very large compared to its self discharge rate. The self discharge rate thus obtained after approximately 600 days amounts to 2 µA at room temperature and 10 µA at +72 °C (see figure 7).

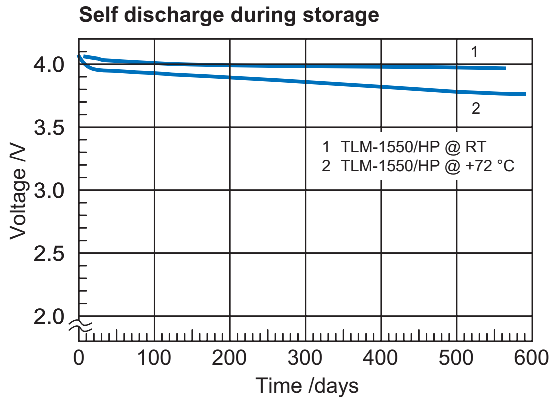

Fig. 7
Voltage during storage of TLM-1550/HP @ RT and @72 °C.

Application example

In a typical application, the new TLM-battery is used as a back-up battery in a telematic emergency call system (see table 2). It starts operation only when the car battery has failed, either due to an accident or due to tampering, for instance when the vehicle was stolen. In this case, the back-up battery enables transmission of an emergency call or location of the vehicle by satellite.

Application	Application field	Emergency call system in GSM mode
Electrical Requirements	U_{min}	6.5 V
Current profile	Basic current Transmit/Receive	< 1 µA Average 420 mA for t_{TR} with 2 A peaks for 577 µs every 4.615 ms
Environmental Conditions and transmission/reception times t_{TR}:	Temperature: -30°C …0°C 0°C …+40°C +40°C …+75°C +75°C …+85°C	t_{TR} (after 10 years storage) 15 min 30 min 20 min 0 min
Battery	Type: Nominal capacity: Nominal Voltage:: Size: Weight:	3 x TLM-1550/HP in series 550 mAh 12.3 V 47 × 52 × 17 mm³ 60 g

Table 2
Requirements for the new TML battery in a typical application.

Safety

Due to its chemical system and its internal construction, the TLM battery has a high degree of safety. The anode is by far not as reactive as the lithium metal which is normally used in non rechargeable lithium batteries. The electrolyte is moderately flammable. When short circuited, the battery develops less heat and is thus safer than comparable other battery systems because it generates the same power from a smaller volume and thus only for a short time. The battery has passed the standardized safety tests, like short circuit, impact, overdischarge. Beyond that, it has also passed further, non standardized safety tests.

Figure 8 shows the behaviour of the TLM battery during a short circuit. This test was conducted at +55 °C. The voltage drops right at the beginning to a small value, the current rises shortly to a peak value of approximately 45 A. It is, however, immediately limited to approximately 20 A by virtue of the shut down separator. After approximately half a minute the battery is exhausted and the current drops. The temperature curve shows a steady increase by altogether approximately 65 degrees to 120 °C. No further observations were made, especially no fire and no rupture.

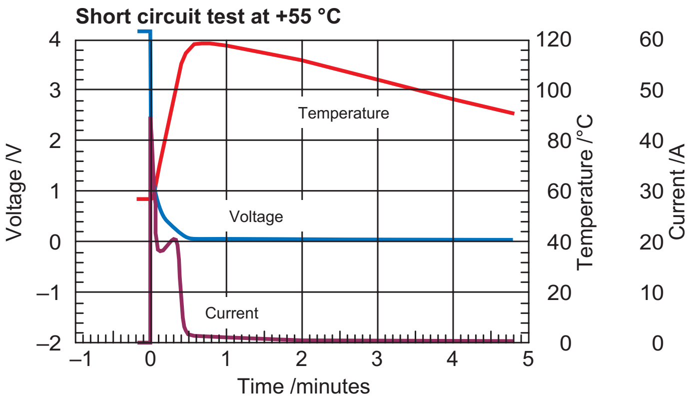

Fig. 8
Short circuit of TLM-1550/HP @ 55 °C.

The impact test is one of 8 tests that lithium batteries have to pass in order to be transported according to dangerous goods regulations. It is described for instance in the International Standard IEC 62281. The test method calls for a metal rod to be placed across the battery. Then a mass of almost 10 kg is dropped from a height of approximately 60 cm onto this configuration. The purpose is to create an internal short circuit. The battery must not catch fire and must not explode during the test. Also, the temperature must not rise beyond 170 °C.

As shown in figure 9, the TLM battery complies with these requirements. After the impact, the voltage drops immediately. This is an indication that indeed an internal short circuit has occurred. The temperature rises within one minute from approximately 30 °C to approximately 90 °C and then slowly decreases.

Further observations were not made, especially no fire and no explosion.

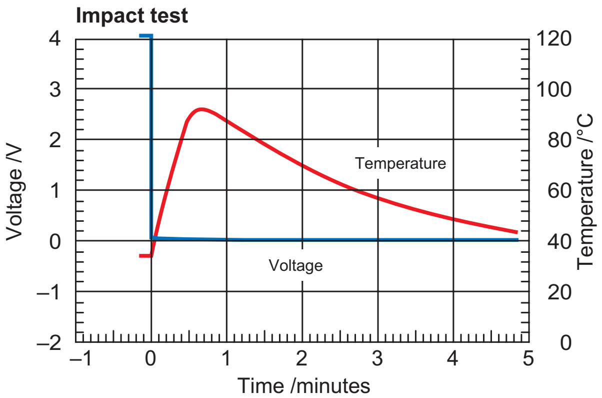

Fig. 9
Impact test of TLM-1550/HP

An overdischarge test is presented in figure 10. Here a battery is connected to an electronic current sink and discharged with a current of 2 A until it is completely discharged. Then the discharge current is continued so that the battery is overdischarged and the voltage is reversed. The purpose of such a configuration is to simulate the behaviour of the battery in a series connection when one battery is empty for whatever reason while the other batteries continue to deliver the full current. This current obviously also passes through the discharged battery unless it has been protected with a by-pass diode as recommended. As shown in figure 10, voltage drops after 450 mAh have been withdrawn from the battery.

The voltage then shortly remains at a value of approximately 1.3 V, then the polarity is reversed to approximately -1.9 V and stabilizes at -0.2 V. The temperature initially rises slowly, then faster to 74 °C and then drops continually. Further events did not occur.

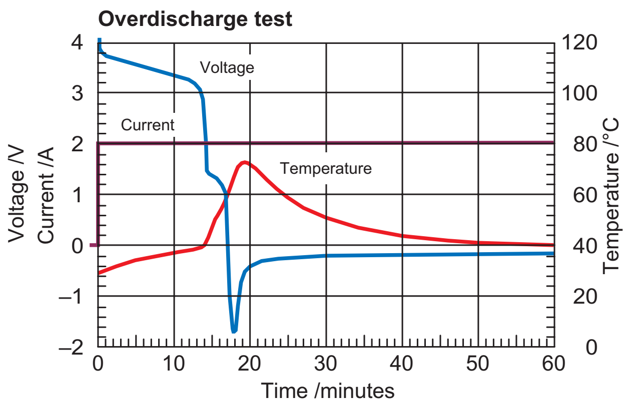

Fig. 10
Overdischarge of TLM-1550/HP with a current of 2 A.

The stability and safety of the ingredients is particularly proven by the high temperature test that is shown in figure 11. 4 batteries were stored in a temperature chamber one after another and observed. The temperature of the battery jacket was recorded. It can be seen that the battery at temperatures up to 165 °C only assumes the temperature of the chamber. No additional temperature rise due to a chemical reaction of the ingredients occurred. Only at 170 °C occurs a temperature rise that is worth mentioning. However, it abates after a short while.

The test proves that there is a safety margin of approximately 80 °C beyond the specified range of operation temperatures. No heat generating reaction was observed during the test. In particular, no electrolyte leakage, no release of overpressure, no fire and no explosion were observed.

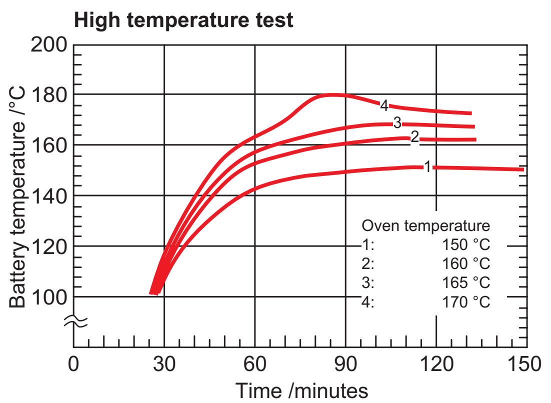

Fig. 11
High temperature test of TLM-1550/HP

Summary

With the new TLM-battery TLM-1550/HP an organic primary AA size battery is made available, that has a pulse current capability of 15 A and a continuous current capability of 5 A. In comparison to other battery systems available on the market, the battery has the best performance data down to –40 °C. It constitutes the smallest high power back-up battery is therefore suitable as emergency battery for telematic applications such as E-call, E-latch, E-brake, stolen vehicle location and others. As safety tests prove, the battery meets all safety requirements. The safety margin exceeds approximately 80 °C beyond the specified range of operation temperatures.