



VISHAY INTERTECHNOLOGY, INC.

LOW VALUE POWER METAL STRIP® RESISTORS

Intelligent Li-ion Rechargeable Battery

Intelligent Li-ion Rechargeable Batteries Utilize Current Sensing Resistors with Ultra Low Ohm, Low TCR, Tight Tolerance, High Withstanding Surge Current and Low Thermal EMF

In the field of portable electronic equipment such as Notebook PCs, mobile telephones and camcorders, the demand for Intelligent Li-ion rechargeable batteries has been showing rapid growth because their high energy density (approximately 1.5 times in volume and 2.0 times by weight compared to Ni-MH batteries), high output voltage (+ 3 V to + 4 V), and low self-discharge rate (10% to 12%/month).

However, to assure the performance of Intelligent Li-ion rechargeable batteries, three inherent difficulties must be taken into account. First, heavy current discharge will cause degraded performance, i.e., available energy will drop down to 90% and sometimes 50% of nominal energy. Second, high internal impedance causes a potential drop which makes it difficult to utilize the expected potential energy at high efficiency. Third, required constant-current and constant-voltage charging is difficult to control.

To solve the above difficulties, various Intelligent Electronic Charger and Monitoring Circuits have been developed that utilize resistive components. (See Appendix.)

Sense Resistor-General Application

For the precise determination of charge and discharge activities of the battery, very stable and accurate sense resistors with the following characteristics are required:

- **Very Low Ohmic Value**

For minimizing energy loss, the required ohmic value is below 100 milli-ohms.

- **Tight Tolerance**

To maintain the total accuracy of the Intelligent Li-ion rechargeable batteries as close as + 5%, - 0% of the total available power capacity, the tolerance of the sense resistor must be $\pm 1\%$ or tighter.

- **Low TCR**

Since the maximum normal operating current is three to four amps, in general, the maximum ΔR due to self-heating must be as low as 1000ppm across the ambient temperature range of 0 to + 40°C. Thus, a low TCR resistor for current sensing is required. See Chart 1 for TCR comparison.

- **Low Thermal EMF**

During the standby mode, a Notebook PC requires 50 to 100 milli-amps to operate its D-RAM and CPU, and a Handycam requires 5 milli-amps to operate its small memory. Therefore, in the standby mode, the thermal EMF of the sense resistor must be low compared to the terminal voltage generated by the current output.

- **Resistance Value**

For minimizing the power loss and charging time, and maximizing the efficiency of the potential energy of the Intelligent Li-ion rechargeable batteries to the connected equipment, the sense resistor must be as close to zero as possible. However, this ideal condition is unrealizable since the limited resolution of the microcomputer requires a certain level of voltage between the terminals of the sense resistor.

The key factors to determine the resolution of the microcomputer are its semiconductor noise and offset voltage. Typical resistance values utilized in various micro-computers are 100, 50, 20 and 10 milli-ohms.

The Vishay Dale® WSL-0805, WSL-1206, WSL-2010, WSL-2512, WSL-0805-18, WSL-1206-18, WSL-2010-18, WSR2 and WSR3 can provide extremely low values down to 1 milli-ohm with one resistor. This saves mounting costs and space, and improves the MTBF of Intelligent Li-ion rechargeable batteries.

In comparison, with conventional cermet chips, four to six chips are needed to achieve very low ohmic values. And with conventional thin film chips, at least two chips are needed due to their low power capability.

Appendix I

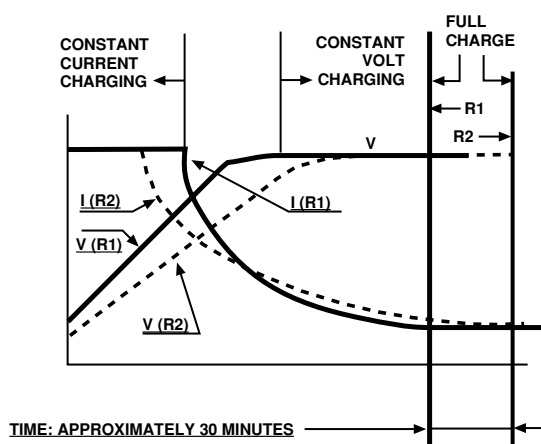
Microcomputers for Intelligent Li-ion Rechargeable batteries

Microcomputers have various functions to maintain an accurate record of the available capacity of Intelligent Li-ion rechargeable batteries.

- To monitor a voltage drop across a sense resistor, connected in a series between the negative battery terminal and ground, to determine the charge and discharge activity of the battery.
- To apply accurate compensations for battery temperature and rate of charge or discharge and self-discharge calculations to provide available capacity information across a wide range of operating conditions.
- To automatically recalibrate the battery capacity or to learn the capacity in the course of a discharge cycle from full to empty.

The sequence of battery charging is first, constant current charging until the terminal voltage reaches 4.1V or 4.2V. Then second, switched to constant voltage charging mode until full charge is achieved. Immediately after full charge is achieved, the sequence must be stopped.

High Ohmic Values Increase The Time For Charging And Causes Large Power Loss



i.e. $R1 = 10$ Milli-ohms; $R2 = 50$ Milli-ohms

Appendix II

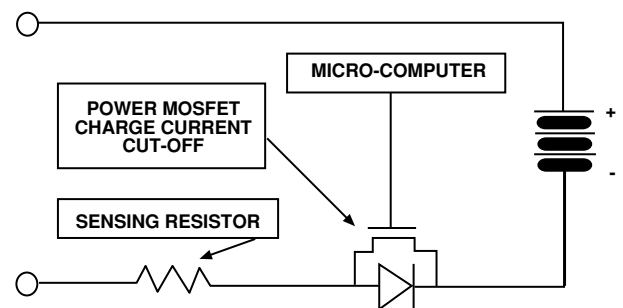
Intelligent Charger Circuits

There are two basic Intelligent Charger Circuits:

• Active Potential – Conventional Type

When the Intelligent Li-ion rechargeable batteries are removed from the equipment, the potential between the terminals is still active (Figure 1). In the case of short circuit by misuse, they could be seriously damaged due to an abnormally high discharge current. Therefore, Intelligent Li-ion rechargeable batteries require protective resistors or fuse resistors to cut off the abnormally high current. This inactivates the circuit.

FIGURE 1: Active Potential Type (Conventional)

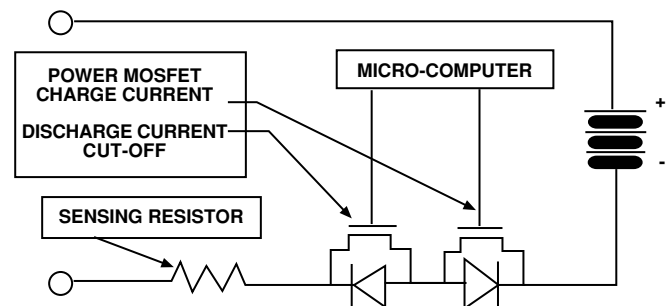


When removed from the equipment, the potential between the terminals is still active. Thus, to protect the charging circuit, fuse resistors which burn out at high currents are used.

• Non-Active Potential – Advanced Type

When the Intelligent Li-ion rechargeable batteries are removed from the equipment, the potential between the terminals is zero (Figure 2). Thus, they do not have a chance of electrical short circuit.

FIGURE 2: Non-Active Potential Type (Advanced)

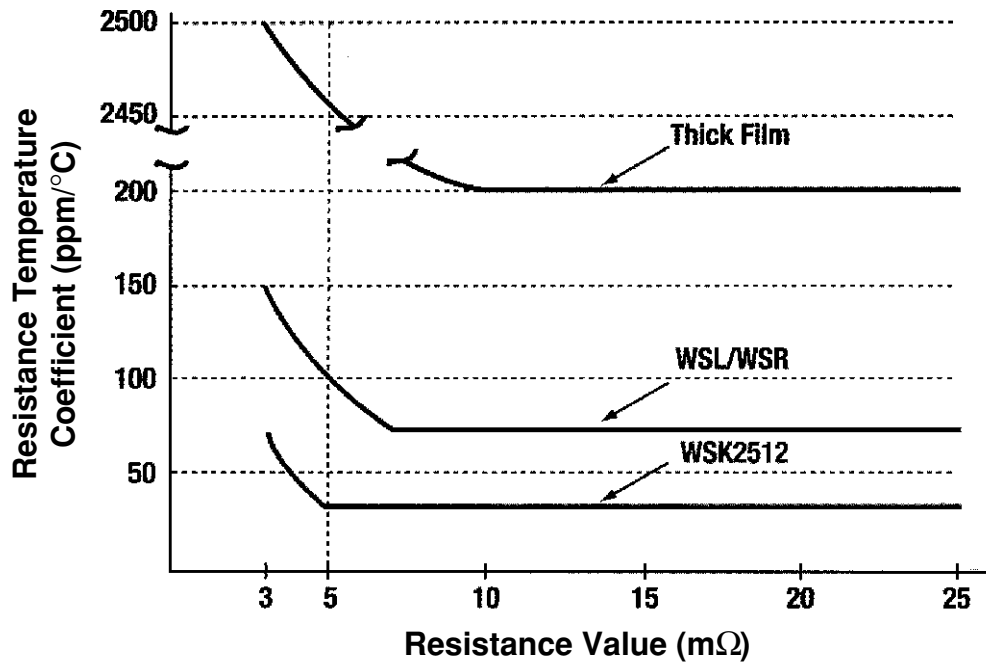


When removed from the equipment, the potential between the terminals is still zero. Thus, the Vishay Dale® Power Metal Strip® Resistor is used.



CHART 1

POWER METAL STRIP - TCR PERFORMANCE



NOTES:

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