Battery State Sensor

1. INTRODUCTION

Recently, the requirements for environmental consideration have been increasing in the automobile industry. Therefore, optimizing the power management in vehicles and other correspondence are required to promote the improvements of the fuel efficiency and the reduction in CO_2 emission.

To deal with them, we have developed a lead-acid battery state sensor with a high-accuracy detection capability of the battery states which is a key device in the power management (Figure 1).

This product monitors the charge/discharge currents, the voltages and the temperatures in a battery by being attached to the negative post of a lead-acid battery.

Based on the information, it estimates the battery states such as the charging rate (state of charge:SOC) and the discharging performance (state of function: SOF) accurately. In this way, it contributes to avoiding battery running out, and to the improvement of the fuel efficiency and reduction in CO_2 emission by the charge control and the stop & start system.

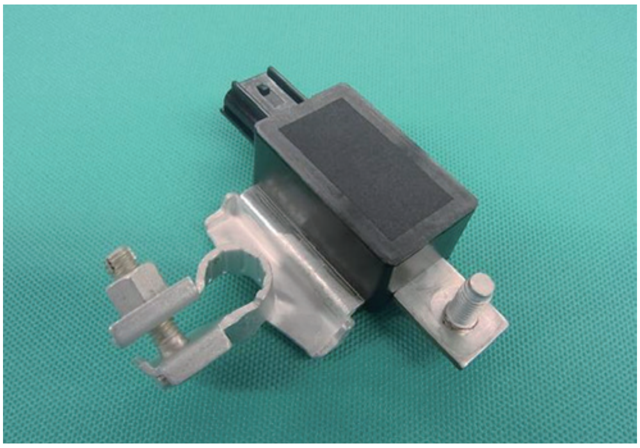


Figure 1 The appearance of the developed product.

2. CHARACTERISTICS

2.1. A High-accuracy Measurement of the Internal Resistance of a Battery

This product is “the world’s first” automotive lead-acid battery state sensor equipped with a pulse discharge circuit. It measures the internal resistance of a battery actively because the discharge timing can be set arbitrarily. Its measurement accuracy is higher (better repeatability) than that of the standard method (it calculates the internal resistance from the current and the voltage at the starter starting.). It also measures the internal resistance in hybrid electronic vehicle (HEV) and electric vehicle (EV) which are not equipped with a starter (Table 1). The internal resistance has a strong correlation with the engine start-up performance (discharging performance : SOF) (Figure 2).Then this product can estimate the SOF accurately by high-accurate measurement of the internal resistance.

Table 1 The accuracy of the internal resistance detection.

Item	Our method (Pulse-discharge method)	Standard method (Starter method)
Measurement accuracy	±0.5 mΩ (using actual equipment)	About ±1.0 mΩ (desktop experiment)
Application to HEV and EV	applicable	Not applicable

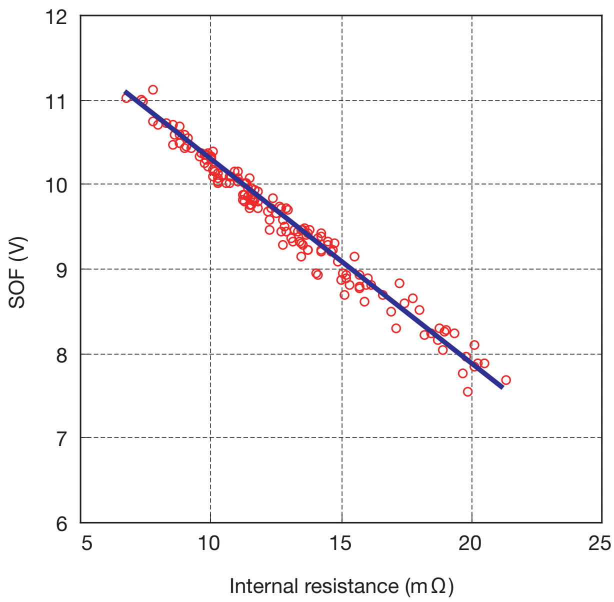


Figure 2 The internal resistance-SOF correlation.

2.2. A Quick and High-accurate Estimation of the Battery States

This product can detect the battery states high-accurately and quickly by sharing the wealth of experience and knowledge regarding automobile lead-acid batteries with a battery manufacturer which is one of our affiliate companies, The Furukawa Battery Co., Ltd. and by developing a unique detection algorithm (Table 2).

Table 2 SOC and SOF detection accuracy.

Item	Our method	Standard method
SOC detection accuracy	±10% (High-speed estimation of stable OCV*, using actual equipment)	About ±15% (Direct reading of terminal voltage, desktop experiment)
SOF detection accuracy (Battery voltage at the start-up of the engine)	±0.5 V or less (Impedance active estimation, using actual equipment)	About ±1.5 V (Passive measurement, desktop experiment)

*OCV: open circuit voltage

An accurate detection of the SOCs of a battery enables an optimal charge control in a vehicle, thus contributes to the improvement of the fuel efficiency.

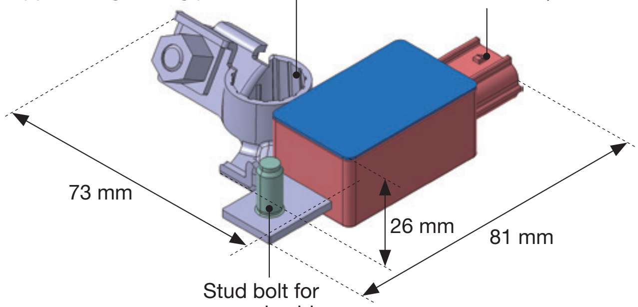
Also, the SOF becomes an indicator of the discharge performance. Estimating SOFs accurately enables the judgment of an engine restart performance, thus leads to accurate warning of battery running out and to decide whether to operate stop & start system or not. Therefore this product prevents battery running out and contributes to the improvement of the fuel efficiency and the reduction in CO_2 emission by stop & start system.

3. PRODUCT SPECIFICATIONS

The following shows the main specifications of this product.

Table 3 Product specifications.

Environmental property	Storage temperature range	-40 – 105℃
	Operation temperature range	-40 – 105℃
Electrical property	Operation voltage range	6 – 16 V
	Current consumption	When operating: 10 mA (Ave.)
		When not operating: 1 mA or less
Telecommunication specification	As per LIN2.0	
Connector specification	Tripolar (+B, LIN and for measuring internal resistance) Terminal size: 0.64 mm, waterproof type	
Applicable standards of battery posts	JIS D 05301 EN50342-2 IEC60095-2 (NORTH AMERICA)	
Measurement Item (Accuracy)	Current: 1 mA – 1500 A <±1%> Voltage: 6 V – 16 V <±2%> Microcomputer temperature: -40℃ - 105℃ <±4%>	
Detection Item (Accuracy)	OCV 〈±0.1 V〉 SOC 〈±10%〉 SOF 〈±0.5 V〉 Battery internal resistance <±0.5 mΩ> Battery temperature <±10℃>	
Product dimension	81 W × 73 L × 26 H mm (Figure 3)	
Product mass	About 80 g	
Applicable battery	See Table 4	



Product dimension: 81 W × 73 L × 26 H mm
Product mass: About 80 g

Figure 3 Product dimension.

Table 4 Evaluated battery.

Type	Manufacturer	Size
Conventional Liquid type	Furukawa Battery GS-YUASA Panasonic JCI	34B17 ～ 80D26 L1 ～ L3
For stop & start system	Furukawa Battery GS-YUASA Panasonic Shin-Kobe JCI	M-42 ～ S-95 L1 ～ L3
UltraBattery	Furukawa Battery	N-55, Q-85, etc.

4. CONCLUSION

We have succeeded in developing a battery state sensor which estimates the battery states accurately and quickly by developing an algorithm and building in a pulse discharge circuit. The product has started mass production in June, 2012.

In the future, we will promote developing a battery state sensor which is not limited to a certain battery type (size, manufacturer) by the self-learning function, and which also can detect the remaining capacity (state of health: SOH).

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