B–17.4 Preparation of System for Adequate Charge and Operation

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Abstract

Wide spreading of electric vehicles (EVs) is anticipated to reduce the emission of carbon di–oxide in traffic use. But, many factors affect the wide spreading of EVs. How to manage battery charging / discharging is not only important to get higher energy efficiency but also important to get longer battery life.

Following devices and methods are developed to clarify the adequate charging procedure to get high charging efficiency and managing procedure to get longer battery life.

State of charge indicator have been made and was tested with the battery installed in the charge/discharge simulator. Universal charger has also been developed to discuss the charging algorithm suitable for every EVs. Unbalance of battery in battery blocks are also discussed.

Key Words Electric Vehicle, Battery, Charge, Maintenance, State of Charge

1. Introduction

Recently, as environmental problems such as air pollution in urban areas, acid rain and global warming are becoming a world–wide problem, great interest is focused on development and practical application of Electric Vehicles(EVs) as a substitution of internal combustion engine vehicles (ICEVs). Especially, zero–emission vehicle raw in California acts as a accelerator for EVs development.

The performance of EVs is gradually being improved through the adoption of technical improvements in batteries, motors, controllers and other components. Traction system including motor and controller has been improved steadily in various EV development programs. As for traction system technology, development step in present situation is close to just before commercialization steps.

To the contrary, improvement in specific energy of conventional battery has been hardly made. Moreover, absolute value of specific energy of battery is very small comparing with that of gasoline. One of the biggest barrier for EVs is its short range. One another hidden barrier is "how to use the traction battery block" which affects efficiency of traction battery.

2. Background of EVs

Energy density of conventional batteries such as lead–acid batteries or Ni–Cd batteries is about 40 to 60Wh/kg and that of gasoline is about 13,800 Wh/kg[1)]. So. it is difficult for electric vehicle to achieve enough range, and its natural that vehicle weight of EVs are 50% up of conventional vehicles. To improve the range is one of the most important Item for electric vehicle.

Figure 1 shows economic efficiency of EVs and ICEVs in Japan. Each cost are calculated based on actual vehicle operating data.
A micro van, which is most popular type of EVs in Japan is compared with the same type ICEVs. Comparison is based on following conditions: At first, vehicles are replaced every 6 years, because of business use. Running distance of ICEVs is assumed to be equal to running distance of EVs.

Due to tax condition in Japan, payment for gasoline is near 3 times of that for electrici–

ty. As for as EVS, vehicle and charger are initial cost. As batteries are replaced every 2 years, one unit of battery is initial cost and two units should be calculated as running cost.

Mass production effect has possibility to decrease the vehicle cost. But battery cost as replace parts increases running cost of EVs. This fact is one of the reason why no EVs are used commonly.

Although rated life of the battery is 500cycles, batteries are replaced every 2 years or less duration due to reduction in capacity. 500 cycles are a life of battery, and not a life of battery blocks. In fact, some report says that life cycle of some traction battery block is below 200 cycles in spite of long rated life of battery.

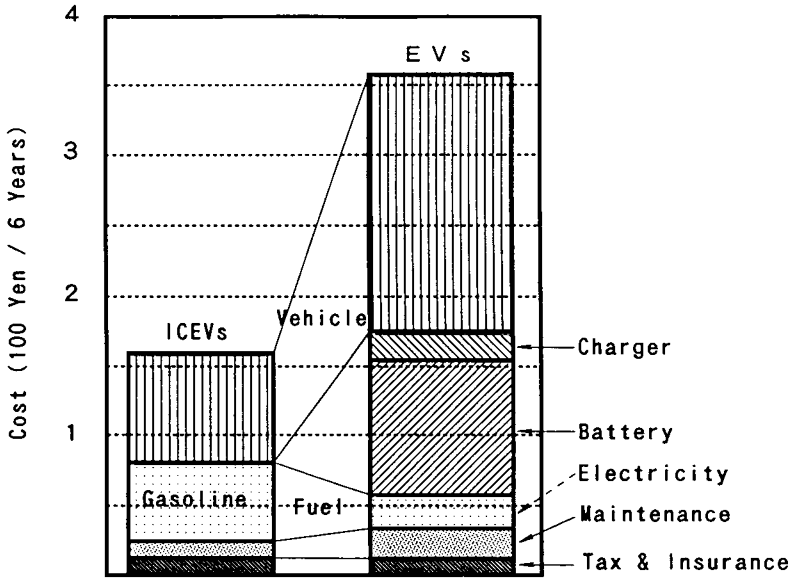

Fig. 1 Comparison of Cycle Cost of EVs and ICEVs

3. State of charge indicator

Due to the limited range of EVs, remained quantity of battery energy is important for user to operate a EVs. Many study on "State of charge" indicator have been conducted by many researcher. But there is no indicator with enough accuracy for practical application. State of charger indicator have been developed and was tested by the battery which was installed in the charge/discharge simulator.

Block diagram of the State of charge indicator is shown in Fig.2. Terminal voltage of battery block, current of battery temperature is fed to CPU via DA converter. Level of state

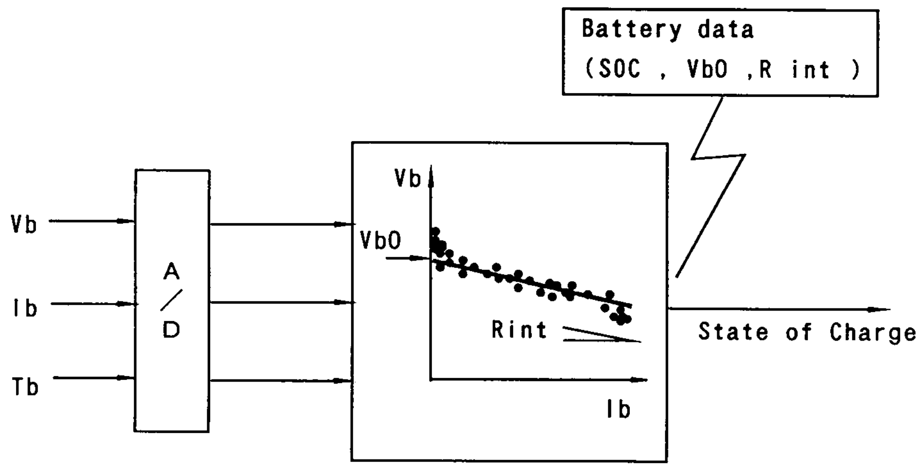

Fig. 2 Block diagram of State of Charge Indicator

of charge is estimated by referring the discharge current v.s. voltage characteristics of the battery. This estimating method is well known and very common method. But, the estimated value has much dispersion, and has some deviation in certain occasions. Developed indicator holds certain succeeding data of terminal voltage and current data pairs, and omit some pair data under the certain conditions. Average value of open circuit voltage of battery and internal registanse of battery are calculated by the data mentioned above. The data pairs held for caliculation are renewed by first-in first-out manner.

4. General purpose charger with high efficiency

Usually, EVs have a charger specially designed for each traction battery block. So, user who uses two or more different EVs has to set different chargers for each EV. General purpose charger has been developed to adopt different EVs with one charger. The charger is composed of 4kW unit DC sources (switching regulator), 1.5 kW unit DC sources, distributing switching circuit and controller. Each unit DC sources generate 80 to 170V(25A max). Two units can operate as 8kW unit; 170V, 5A in a parallel operation, 340V, 25A in a series operation. Output voltage, limit current and operating mode are controlled by CPU (or externally). This charger has 3 output port (3 EVs can be connected at the same time). Charging sequence is controlled so that the peak power duration of each unit does not duplicate and total consumed power will be limited below the main source capacity. This feature enables user to charge two or three EVs under the limited main capacity.

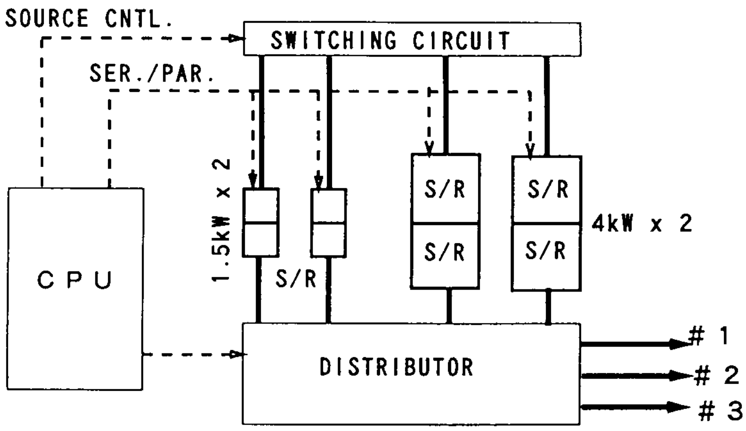

Fig. 3 Block diagram of the Charger

Charging efficiency is one of the most important factors for EVs. As a common sense of EV driver, we want to set EV in fully charged condition. After short trip, one may charge it if he has enough time to charge. This forces a charger to operate in low efficient condition. Charger changes in high power rate only when battery is empty and its duration is short. In remaining periods, charger

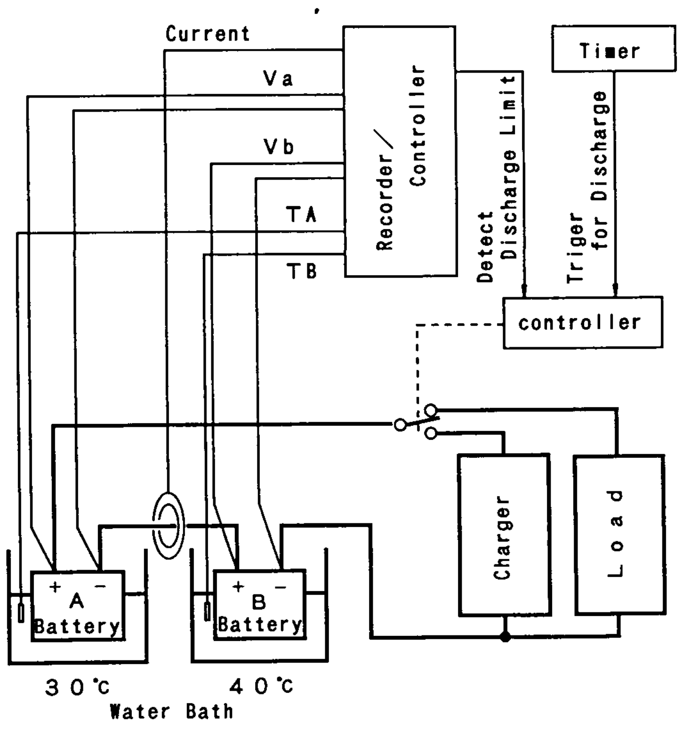

Fig. 4 Block Diagram of Test Rig

operates in low charging power. In this period, energy spent by charger itself is not negligible small. This problem is solved by switching over to mini changer when charging current decreases. Block diagram of the charger is shown in Fig.3.

5. Unbalance in traction battery block

Some decrease in life cycle is caused by heat damage of batteries, such as quick charge. And some decrease in life cycle may be caused by unbalance in characteristics of batteries or unbalance of battery temperature. Unbalance in battery temperature is often occurred in battery blocks installed in actual vehicle.

Effect of unbalance temperature on battery life has been studied. Figure 4 shows the block diagram of test rig. Same type batteries are installed 2 water bath. One is set 30°C, the other is set 40°C. Charging and discharging is repeated automatically. Charge is done assuming that battery block temperature is 35°C. Discharge process is terminated when terminal voltage of either battery falls to determined voltage.

Tendency of capacity variation is shown in figure 5. Below 20 cycles, battery in high temperature is good in capacity. But after 20 cycles, capacity of battery in high temperature decrease in high rate. So, unbalance in temperature causes unbalance in capacity.

If unbalance in capacity is occurred in traction battery block by some reason, conventional charging process leads battery block to be damaged. Conventional charger is controlled by terminal voltage of battery block and not by terminal voltage of each battery. This is an another problem which shorten the battery life cycles. Study on this problem is scheduled next succeeding 3 years.

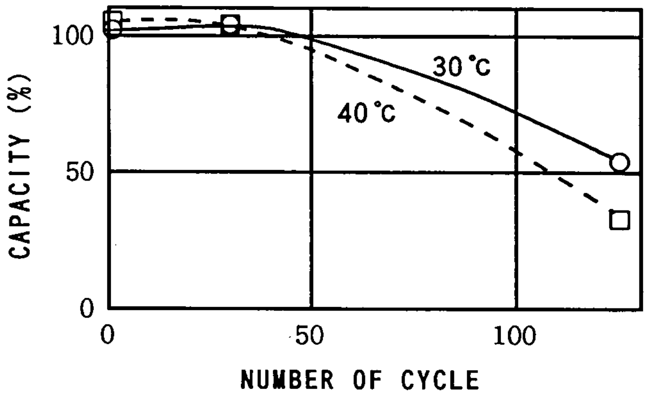

Fig. 5 Effect of Temperafure on apacity

6. Discussion

One of the biggest barriers for EVs may still be traction battery. But no one knows the possibility of traction battery with enough ability. We must discuss application of EVs with existent battery. And we must discuss how to optimize the energy consumption of whole EV system.

To apply EVs with conventional battery as traffic system, application technique of battery is one of the main barrier. Firstly, we must discuss following two procedures to solve the problem.

1) It is important to make a procedure to use whole ability of conventional battery.

2) Energy losses to be produced in charge/discharge process is significantly large , so it is important to make a procedure by which every one obtain optimal changing/ discharging conditions.

References

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