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Monitoring fleets of electric vehicles: optimizing operational use and maintenance

P. Lenain, M. Kechmire, J.P. Smaha
Oldham France S.A., Z.I Est, Arras 62033, France

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Abstract

Electric vehicles can make a substantial contribution to an improved urban environment. Reduced atmospheric pollution and noise emissions make the increased use of electric vehicles highly desirable and their suitability for dedicated fleets of vehicles is well recognized. As a result, a suitable system of supervision and management is necessary for fleet operators, to allow them to see the key parameters for the optimum use of the electric vehicle at all times. A computer-based data acquisition and analysis system will allow access to critical control parameters and display the operation of chargers and batteries in real time. Battery condition and charging can be followed. Information is stored in a database and can be readily analyzed and retrieved to manage extensive charging installations. In this paper, the operation of a battery/charger management system is described. The effective use of the system in electric utility vans is demonstrated.

Résumé

Le véhicule électrique s'inscrit dans une large réflexion au plan de l'écologie et du confort du cadre de vie. Ses facteurs de réduction de la pollution atmosphérique et du bruit feront de lui un objet d'utilisation courante et sa vocation de flotte captive est indiscutable. Aussi, un système de supervision et de gestion devient l'outil indispensable pour les exploitants de flotte captive afin de leur permettre une visualisation des paramètres essentiels à la bonne utilisation du véhicule électrique. Le système informatique permettra d'accéder à plusieurs fonctions de contrôle et de visualisation du fonctionnement en 'temps réel' d'un ensemble poste de charge-véhicule, et à l'exploitation des données ainsi recueillies, afin de suivre leur évolution durant la charge. Les informations peuvent être stockées dans une base de données à partir de laquelle on générera l'ensemble des informations nécessaires à la bonne gestion de la salle de charge. Cet article décrit comment le système de gestion sera utilisé.

Keywords: Electric vehicles; Maintenance; Operational use

1. Introduction

Experience gained with fleets of electrically-powered lift trucks for materials handling has provided a basis for a computer-based management system for batteries, chargers and trucks. The overall objective is to optimize truck availability, to reduce costs, and to identify preventative maintenance requirements. The remaining capacity available in each vehicle and the required charging time are important factors. The computer management system has been adapted to meet the specific needs of road-going electric vehicles keeping in mind the specific needs of battery and charger management.

Electric vehicles are the ideal solution for pollution caused by traffic in the urban environment. There are many issues still to be resolved regarding electric-vehicle performance, e.g., the provision of suitable infrastructure and the development of communication standards. Applications will, however, expand rapidly if supporting systems are readily available, particularly for use by municipalities, community services, public utilities and larger corporations. The use of computer-based management systems becomes essential for fleet managers in order to optimize operational use and maintenance.

The system allows: (i) display of all measured parameters as required (i.e., battery voltage, cell/monobloc voltage, current, temperature, capacity remaining, capacity used and capacity returned); (ii) display of control data; (iii) analysis of the stored information using a standard database; (iv) data storage and retrieval. In this paper, the systems used for connection and communication between the vehicle and the off-board

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charger (OBC) will not be discussed, but the information transmitted by the battery to the OBC will be described in detail.

2. System description

2.1. Overall configuration

The schematic arrangement of the system is shown in Fig. 1. All of the information regarding the charging installation is obtained through a supervisory station designated as Vision 2000. The central station requests data from multiplexers MUX1, MUX2, and so on, from each charging point.

The OBC is equipped with an interface to permit it to communicate with the central station through a single serial link, and multiplexers (MUX1, MUX2). The battery is equipped with an identifier shown in Fig. 2 which will store in memory all of the information necessary for optimum utilization.

In the absence of an agreed standard, a communication protocol between the OBC and the vehicle has been defined. A single connection is used for the communication with the battery (Fig. 3). The recharge carried out by the OBC has the precise voltage, current, time profile required by the battery. Ideally, the battery should have an intelligent system, in order to make the best possible use of the charging unit and be able to demand the correct profile from the OBC.

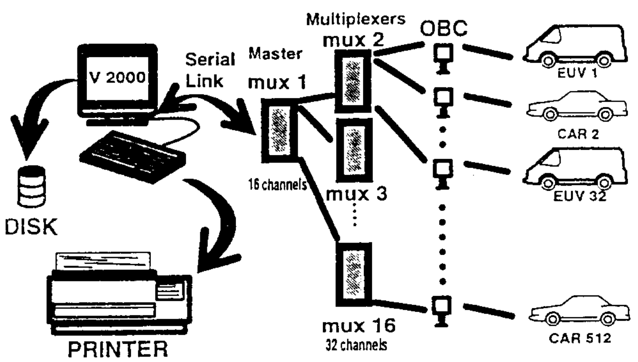

Fig. 1. Schematic of battery charging installation. OBC: off-board charger; EUV: electric utility van.

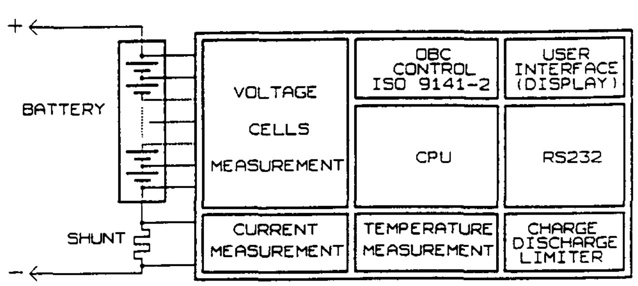

Fig 2. Schematic of intelligent battery.

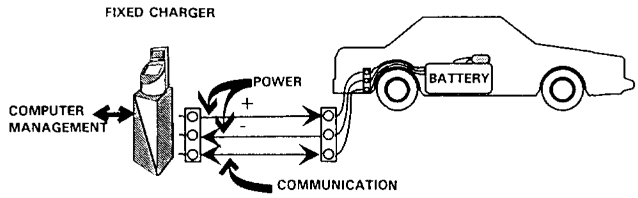

Fig. 3. Communications protocol between OBC and vehicle.

2.2. Management of data to provide an intelligent battery

Intelligent batteries have the benefit that each battery manufacturer can define the best charging characteristics and the best way of making use of the charger. This will also help ensure that the operational parameters necessary for long life are followed.

All of the data stored in the battery memory will be transmitted and stored in the supervisory system. This information will allow the user to know the remaining capacity in each battery before using vehicles, and allow the best choice to be made.

The intelligent battery contains optimum profiles for each type of battery. The concept used in Vision 2000 avoids the charger having to be updated with an ever-increasing amount of data if the charging algorithm is not contained within the battery. The charging current is most appropriately controlled by the intelligent battery, with the charger simply responding to the commands it receives (Fig. 4).

At the charging station and after diagnosis, the battery communicates its identification, as well as the whole of the information contained in its internal memory, as follows:

- number of the battery
- number of the vehicle
- type of vehicle
- duty carried out
- time in operation
- percentage of charge

All of these data will provide the operator with the information required to manage the fleet. A portable display, able to handle the most relevant parameters, will allow real-time control of the installation and enable the supervisor to intervene at any time in the event of faults.

The computer display provides details of all key parameters for each charging station and battery, i.e.,

- charge current
- battery temperature
- Ah returned to the battery
- time before the battery is fully charged
- time on charge
- percentage of charge
- vehicle identification
- charger identification
- battery identification

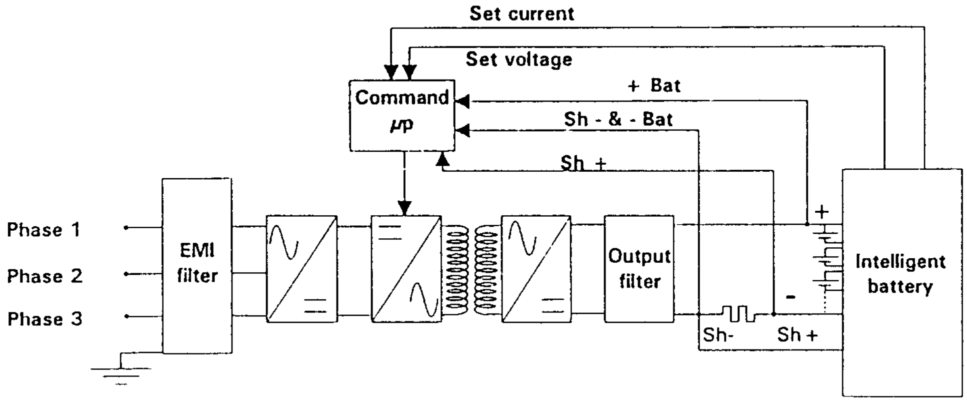

Fig. 4. Schematic of battery current regulation.

3. System operation

3.1. Management and maintenance services

A large charging installation with a significant fleet of electric vehicles can easily become very complex without adequate management tools. In use, the operator has to find a cost-effective way of achieving control. There are two ways of achieving this; either by traditional methods or by computerized data-collection and analysis. Traditional methods rapidly lead to inefficient operation as the park becomes larger, and computer-based solutions become essential to obtain high levels of productivity and utilization.

3.2. Faults and maintenance

The data-collection system will obtain information in real time to manage and memorize all faults as they occur which may restrict the operation of the fleet. Battery faults may cause either immediate problems with lower capacity available, or longer-term difficulties that reduce the life of the battery. Systematic analysis of these problems will provide data for preventative maintenance, improved battery life and economy in operation. The events recorded may include:

- battery overcharged
- battery inspection required
- battery inspection carried out
- battery over-discharged
- excessive battery temperature
- extended storage without maintenance charging
- other specific faults

An example of the display of accumulated faults is shown in Fig. 5, which can be analyzed further by cause.

As has already been indicated, the lifetime of the battery is very important and can be strongly influenced by preventative maintenance. The computer system can contribute to the knowledge of the number of cycles expired and all the necessary parameters to calculate, through an appropriate algorithm, the remaining life of the battery. This will also contribute to better fleet-management.

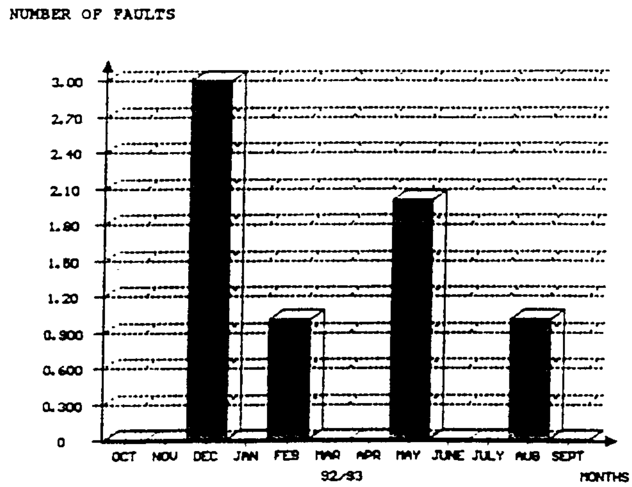

Fig. 5. Accumulated battery faults in electric-vehicle operations.

The following parameters are necessary to keep a check on battery condition:

- measurement and storage of charge/discharge characteristics at different temperatures
- charge/discharge cumulative Ah
- number of charge/discharge cycles
- calendar age of the battery

A continuous record of Ah returned and Ah used, together with the data above, will provide an accurate measure of the percentage of available charge.

Battery characteristics can be followed in real time (Fig. 6), i.e., voltage U (V), current I (A) and temperature T (°C). The change of U, I and T during charging can be followed and the state-of-charge assessed.

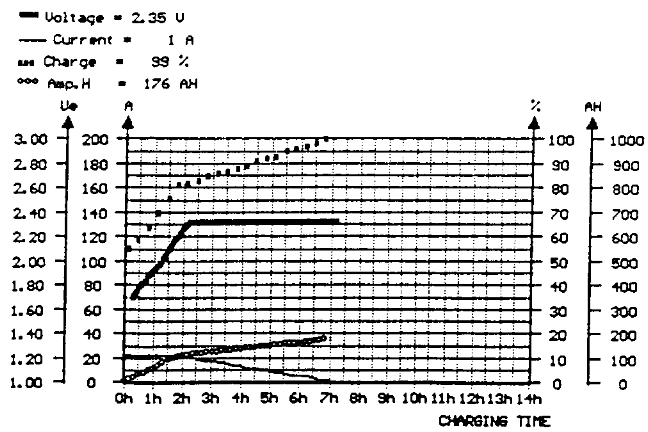

Fig. 6. Monitoring of battery characteristics.

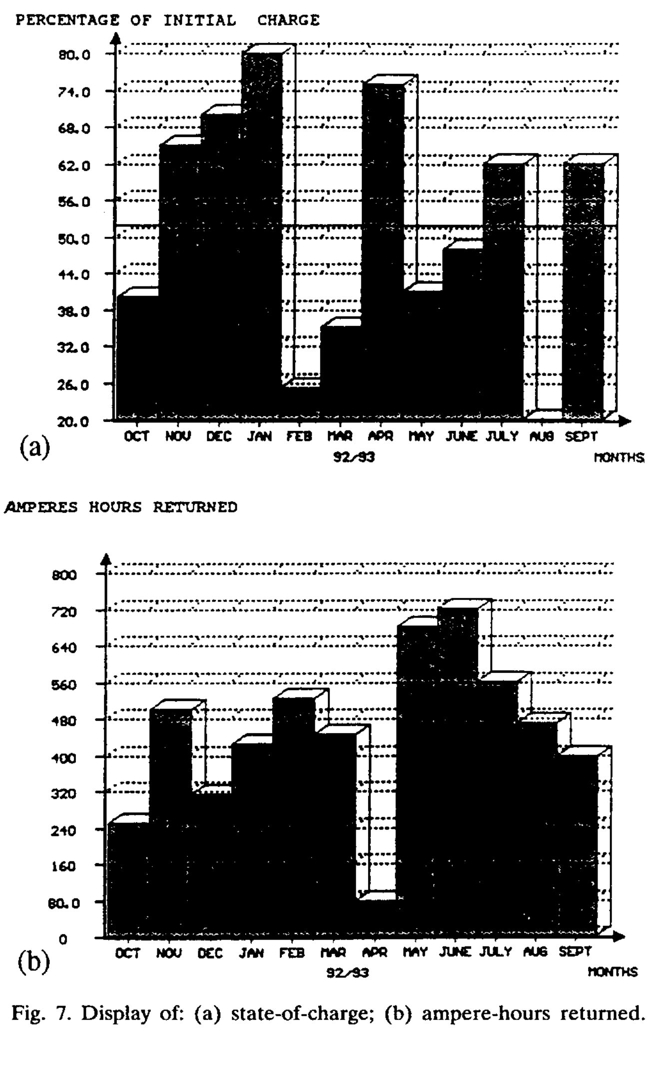

Fig. 7. Display of: (a) state-of-charge; (b) ampere-hours returned.

The data also allow histograms to be constructed to give an overall picture of the fleet. These can include:

- Ah returned
- average voltage per battery
- end of charge voltages
- percentage of charge
- number of cycles

An example of a display for state-of-charge is shown in Fig. 7(a), and ampere-hours returned in Fig. 7(b). The whole data-base is available for transfer to other systems, as required, and may be analyzed by DBASE or EXCEL software.

4. Conclusions

Computer-based battery-management systems for electric-vehicle fleets are an effective way of improving availability and efficiency. Systems are being developed to record and analyze operational parameters and provide charge inputs tailored for each battery. In practice, each user has different requirements and one of the features of a software-driven battery-management system will be easy adaptability for particular users. The system has to be user friendly so that operators can obtain the data required to meet their requirements and provide efficient overall management. Systems of this type have been proven for materials-handling applications and exploitation for electric-vehicle fleets will provide a strong impetus in this sector.

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