Development of a Charge Controller for EV Charging Services

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Abstract

EVs and PHVs are about to start spreading due to growing environmental awareness. However, since significant electric power is required to charge these vehicles, it is not easy to install new charging facilities in the car park of an existing apartment building.

Accordingly, we have developed a charge controller as a key device for realizing the provision of safe, secure and convenient charging services so that a user can reliably use charging services outside the house, even for EVs and PHVs, just like refueling a gasoline vehicle. A single charge controller can control multiple chargers and enables not only support of charge operations but efficient management of authentication/billing and charger operation through collaboration with EV charging cloud services.

Keywords

environment, electric vehicle (EV), charge, control, cloud, billing, authentication

1. Introduction

We are gradually coming to see electric vehicles (EVs) and plug-in hybrid vehicles (PHVs) in our cities. According to statistics of the number of electric vehicles owed (estimated) [1] by the Next Generation Vehicle Promotion Center, the number of EVs and PHVs domestically owned was 16,900 units in FY 2010 vs. 8,600 units in FY 2009. This shows that the figures are small yet doubled. In addition, when the Tokyo Motor Show was held at the end of 2011, many new models of EVs and PHVs were released by domestic and foreign automobile manufacturers, showing that these vehicles are steadily gaining in popularity.

On the other hand, since the charging infrastructure (**Fig. 1**) required for charging EVs and PHVs is still immature as a market, its maintenance is an urgent task.

We see some charging infrastructure is open free of charge in public offices and commercial facilities. However, the following mechanism is considered to be required to mature the market fully: the charging service business operator who provides the charging opportunity has to actively maintain the charging infrastructure while a beneficiary pays the costs.

NEC has planned and developed a "charge controller" to be used presumably by a charging service business operator when charging services are provided to EV and PHV users. It is introduced in this paper.

While the charge controller guides a charger's usage so that EV and PHV users can use it safely and securely, it also enables user to conduct authentication and billing in cooperation with cloud computing and the efficient operation management of the charger.

Section 2 describes the charging infrastructure required to provide the charging services for which this charge controller is commercially produced and planned. Sections 3 to 5 describe the overall system configuration of the charging infrastructure to meet the requirements, features and functions of the charge controller.

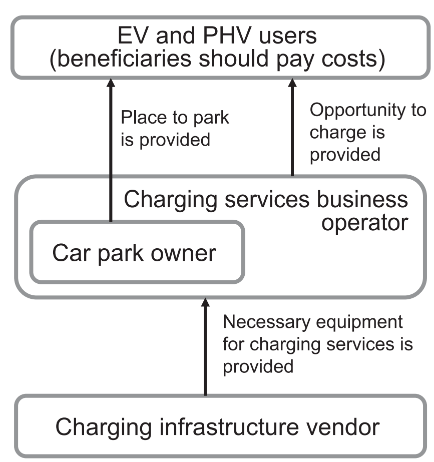


Fig. 1 Charging infrastructure.

2. Requirements for Charging Infrastructure

Charging infrastructure basically provides an opportunity to charge all EV and PHV vehicles and needs to have a means of settlement to impose cost burdens on EV and PHV users according to its use.

Accordingly, this section describes the following three items as preconditions for the examination of requirements: (1) classification of EV and PHV charging systems, (2) electricity costs per charge and (3) classification of settlement methods. In addition, the needs of presumed charging infrastructure users (e.g. EV and PHV users, car park owners, charging service business operators) are described.

2.1 Premises for the Examination of Charging Infrastructure Requirements

(1) Classification of EV and PHV charging systems

Currently, EV and PHV charging systems come in three types: quick charging, regular charging, and wall outlet (**Table 1**).

As shown in Table 1, the charging capabilities and the requirement or non-requirement for an in-vehicle charging cable depend on the type of charger used. In addition, the types of chargers that are usable depend on the type of EV or PHV.

Therefore, it is necessary for the charging infrastructure to select one of the optimal chargers according to the places where EVs and PHVs stop and the needs of users and car park owners, including stop hours.

Table 1 Classification of charging systems.

Type of charger	Availability		In-vehicle cable	Introduction costs	Charge capabilities
	EV	PHV			
Quick charger	○	×	Not required	Expensive	up to 50 kW
Regular charger	○	○	Not required	Average	up to 3 kW
Wall outlet	○	○	Required	Inexpensive	up to 3 kW

Table 2 Classification of settlement methods.

Media	Examples of use	Settlement amounts	Maintenance work	Maintenance load
Cash	–	–	Money collection and change replenishment Remote monitoring	Large
Magnetic card	Credit card Debit card	Large	Maintenance of contact reading part Remote monitoring	Average
Contact IC card	Credit card	Large	Maintenance of contact reading part Remote monitoring	Average
Non-contact IC card	Electronic money	Small	Remote monitoring	Small

(2) Electricity cost per charge

For example, the following is the electricity bill when Nissan Motor's EV “Leaf,” whose battery capacity is comparatively large, is charged from zero to full charge:

Battery capacity (24kWh) × electricity cost (approx. 25 yen/kWh) = around 600 yen (per full charge).

For this reason, consumers are expected to repeatedly pay a small amount of money compared to when refueling gasoline vehicles.

(3) Classification of settlement methods

Mechanisms exist for using cash, magnetic cards and IC cards as settlement media, similar to charging at vending machines and gas stations. An appropriate method is selected and used depending on the application (**Table 2**).

We believe a non-contact IC card with a small maintenance load is suitable for EV charging infrastructure to develop more charging stations for paying a small amount of money in various places where EVs and PHVs stop by.

2.2 Charging Infrastructure Requirements

It is necessary for charging infrastructure requirements to consider the viewpoints of both charger users and operators such as car park owners and charging service business operators. It is important to keep these requirements in mind when the charge controller is developed.

We especially focused on the following requirements:

(1) Users' viewpoints

- Safe, secure and simple equipment
- Easy-to-use and intuitive user interface (hereinafter, "UI") for those who operate chargers for the first time and are unfamiliar with IT equipment

(2) Operators' viewpoints

- Scalability to support an electric power peak cut
- Scalability to support various existing/new chargers
- Mechanisms for unattended operation 24 hours a day, 365 days a year

- Consideration of reliability and operability for long-term operations
- Consideration of environmental resistance, assuming outdoor installation

3. System Configuration

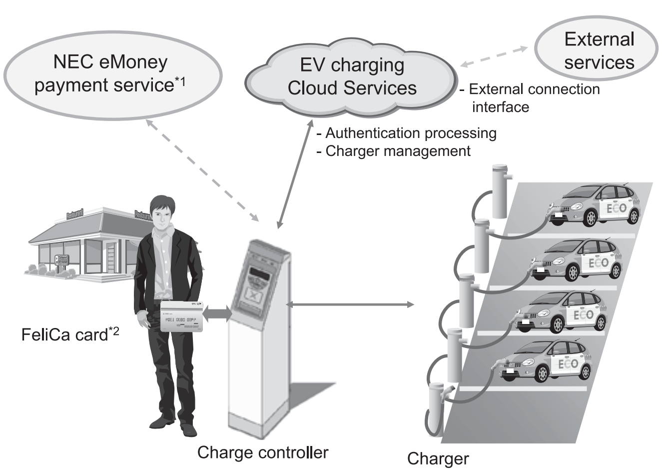
Fig. 2 shows the overall system configuration of the charge controller.

1) **Charge controller**
2) **Charger (quick charger/regular charger/wall outlet)**
3) **EV charging cloud services**
   This system has membership information, charger information and various databases to manage the overall integrated system information.

This system configuration is examined and the main points described below.

(1) Physical separation of charge function and information processing function

The system is configured to separate these functions. The charger basically has the charging function only, while the information processing required for charging services, such as member authentication, UI for charge operations, management and control of the charger, center communication and the like, is realized in cooperation with the main charge controller and EV charging cloud services.



*1 The NEC eMoney Payment service is currently provided by NEC.
*2 FeliCa is a registered trademark of Sony Corporation.

Fig. 2 System configuration of charging infrastructure.

Accordingly, EV and PHV users can operate a standardized UI charger even when the various existing and new chargers (quick, regular and wall outlet) have, for example, various UIs for charge operations. In addition, since a simple charger can be selected, having only a charge function and a simple communication function, capital investment can be reduced when several chargers are installed in one place.

(2) EV charging cloud services

Since the minimum functions required for charging services, such as member authentication and charger management, are provided as cloud services, the costs required are for system development and the operations of the charging service business operator.

In addition, external service connections are interfaced so that services can be enhanced by each charging service business operator.

(3) Considering future cooperation with electronic money settlement services

To support the future of electronic money, our multi-service reader/writer is adopted in the main processing unit of the charge controller. With this we have a rich proven track record in electronic money settlement services, such as beverage vending machines.

Since the multi-service reader/writer has an online add-on service function, even when future forms of electronic money settlement are requested it will not be necessary to change hardware, only update software.

4. Charge Controller Features

We believe that it is necessary for the charge controller to be a product with a universal design so that a wide range of EV and PHV users can easily use it, including for public use, outdoor installation and unattended operation, regardless of age or gender.

Then we developed the product from the planning and design stages in collaboration with the following members, who have a track record and know-how with user-oriented design considering ease of use:

- **NEC Design & Promotion**
  In charge of charger housing and UI design due to its track record for universal design in service terminals, such as ATMs, POS and quick chargers.
- **NEC Engineering**
  In charge of hardware, including power supply, net-

work and housing, and application development due to its track record in various social infrastructure in general, for public use and outdoor installation from the seabed to space.

The following describes the features taken into account for planning and development:

(1) Features of the external design

For the charge controller's external design, we have formulated a basic concept emphasizing visibility and operability for users.

Since the color green is used for external designs to show an environmentally friendly image and the control surface can optimally adjust its height on an inclined surface, high visibility and operability are secured for users in various conditions (**Fig. 3**). Touch switches also used in home appliances are employed for the control unit to achieve smooth operations (see **Photo**).

In addition, the charge controller is made in an environmental resistance design for outdoor installation and is constructed to conform to IP55 [*1] for water- and dust-proof characteristics.

(2) UI features

Since the UI was planned to support unattended operation, it was designed to be intuitive, easy to understand and easy to operate even for those who are using it for the first time.

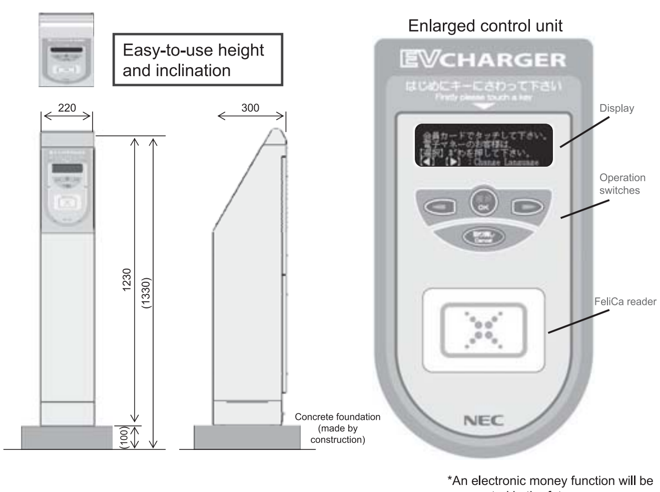


Fig. 3 Charge controller external appearance.

Photo Charge controller external appearance (left: overall view, right: control unit).

- A bright and easy-to-see vacuum fluorescent display with 16 columns × 4 rows
- Simple operation buttons ("Right," "Left," "Enter" and "Cancel")
- Optimized control logic enabling use with fewer operations
- Easy-to-understand expressions and descriptions for those who are unfamiliar with IT equipment

5. Charge Controller Functions

(1) User management functions

Regardless of membership and the type of electronic money used, since the user is identified when the FeliCa card is first waved, this function displays to the screen according to that user's usage conditions of the charger.

(2) Charger communication functions

When communication is made between the charger and the charge controller, it is possible to monitor the fitting condition of the charge connector, current, electric power, etc. It also enables to control the charger, such as a charging start/stop status and specifying the current value.

[*1] 1 IP (International Protection) is a specification based on IEC60529 for devices such as machinery and equipment, representing them by a grade for their protective structure against the intrusion of solid foreign objects or liquids.

(3) Multiple charger controls

Currently, one charge controller can control up to five regular chargers. In the future, we will enhance our charge controller to cope with the co-existence of quick chargers and regular chargers and also increase the number of chargers that can be controlled (approx. 30).

(4) Communications function with EV charging cloud services

It is possible to send various information to EV charging cloud services as required, such as the power used amount and its time together with authentication process information and also power demands at each power receiving point in addition to charger operation status information. Moreover, various settings information can be downloaded from the EV charging cloud service.

6. Conclusion

In the field of EV charging infrastructure, where sufficient deployment is imperative to cope with the dissemination of EVs and PHVs, NEC will promote the planning and development of a charge controller under the best use of our development technology and expertise accumulated in a wider range of product markets, such as EV charging cloud services, embedded systems, etc., to contribute to the dissemination of EVs and PHVs in the future.

We expect that our charge controllers will be widely used among consumers to realize an information society that is friendly to humans and the Earth.

We will continue our ongoing efforts to provide superior products and services by feeding back more needs from users who experience them into subsequent products.

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*FeliCa is a registered trademark of Sony Corporation.

Reference

1) Next Generation Vehicle Promotion Center, "Statistics of the number of possession, production and sales of electric vehicles, etc." http://www.cev-pc.or.jp/NGVPC/data/index.html

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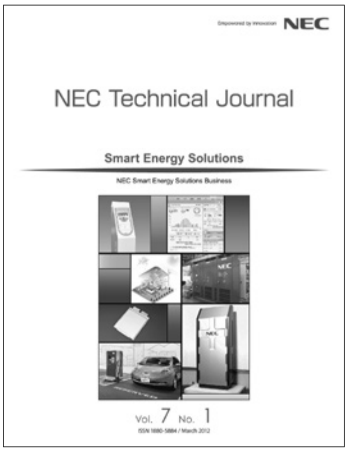

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