Electric Charging Station in Hong Kong

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Abstract

In this paper, an Electric Vehicle (EV) charging system, which is jointly designed by the research center and local power-distribution company, would be presented. The system consists of a number of Charging Points (CPs), a control unit, a user-interface and an electronic payment mechanism. The CPs are grid-connected and allow power electronics connections for Battery Charging. Power supplies are controlled and monitored simultaneously by the control unit. Meanwhile, the charging system provides a user-interface that allows customers to select the desired charging time and read the charging status. The CPs are connected to the charging system via Ethernet thus the number of CPs could easily be extended once the power distribution line is established and CPs is connected to the grid. Electrical parameters, such as line voltage, current, power factor, etc. could be also acquired via Ethernet. The prototype was later developed into a commercial product with an electronic payment mechanism implemented and has been opened to public use for months.

Keywords: EV charging station, electronic tariff payment, time-based charging, single-phase charging

1   Introduction

Invention of Electric Vehicles has benefited us in many aspects. Undoubtedly, EV provides a high-efficiency, no exhaust harmful gases and silent driving experience to drivers.[1] In Hong Kong, due to the government environmental-friendly policies, EV drivers enjoy an exemption from the Vehicle First Registration Tax which strength EV advantages to even cost-effective.[2]

Charging Stations in Hong Kong start in operation in 2009. As a fundamental common energy refuel device for EV, charging stations built would be standard ac 13A domestic power-supplied and located in different districts. The paragraphs below introduces the present public charging stations in Hong Kong, its designs, operations, and how they are distributed in different districts.

Status of healthiness of charging system could be recorded and it would be a useful indicator for trouble-shooting.

2   CLP Charging Stations

2.1   Objective

The EV charging system aims to provide system controllable power supply sockets which users would be able to charge their EV at car parks. It facilitates users to get their EVs batteries charged nearby thus expands the reachable areas. The whole charging system is decomposed into several function parts, which aims to facilitate charging station operators and installation workers in installations, trouble-shooting, maintenance and protection. Meanwhile, security

and safety are two major concerns when power is delivered at a controllable, stable and consistent manner. An electronic payment mechanism has been implemented into the charging system for future commercialization, which customers should purchase the power delivery durations.

2.2 System Requirement

With a tremendous popularity of using RFID as electronic payment in Hong Kong, this technology would be adopted for transaction process and customers' identification. Transactions of tariff, EV drivers' identification would be recorded, updated by the RFID system and the recorded data would be transferred to server. At the same time, blacklist of RFID and updates of RFID system firmware would be prepared by server and downloaded by clients. For any electronic payment mechanism, amount of payment versus customers' unused charging time would be controversial and lead to a combinations of scenarios in charging progress.[3] A resume charging characteristic is implemented which prevent lost of elapsed charging time in case of accidental unplugging. Different Charging Points status, power delivered through socket outlets and errors would be logged and reported to a centralized server hourly for operators' immediate corresponding actions. Since charging points are grid-connected to standard ac system for convenient expansion of the scale, only single-phase domestic-power supply to EV batteries at a board of locations at present stage. The charging stations could also cater high-power three phase fast charging for future development.

2.3 Design Specification

2.3.1   Hardware

A Kiosk with touch screen panel computer provides a graphical user interface and information for user to select corresponding Charging Point, its current status and the pre-defined charging time interval if the Charging Point is available. The whole charging system is composed of the following functional parts. They are: 1. The Charging Kiosk for user-interfacing, 2. Charging Points (CPs) for power delivery, 3. Data Switch Box (DSB) for control and 4. a server for monitoring and data transfer with individual Charging Kiosks. Figure 1 shows the system block diagram of each functional part.
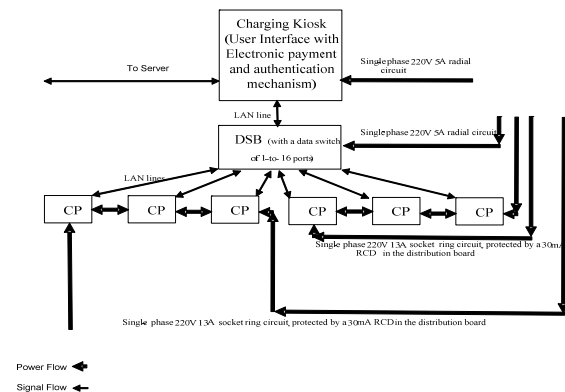

Figure 1: System block diagram for the EV Charging Station

The Charging Kiosk consists of several interfaces with users, control units and the server. A panel PC would handle the interfaces. Graphical user-interface is developed which users are allowed to make queries on current connected available charging points directly with the aid of the touch screen. The Kiosk also included the RFID reader and printer for payments and receipts printing. Status of the CPs would be acquired by polling the corresponding DSB control units. Energy consumed at particular CPs, charging durations would be recorded. All these data would be logged and sent to server regularly. Daily transaction, blacklist of RFIDs and reader firmware upgrade files would be uploaded or downloaded to server via phone line modem to ensure security. Figure 2 shows the schematic on the Kiosk, control unit and the front-end CP which give a glance of the EV charging station system.
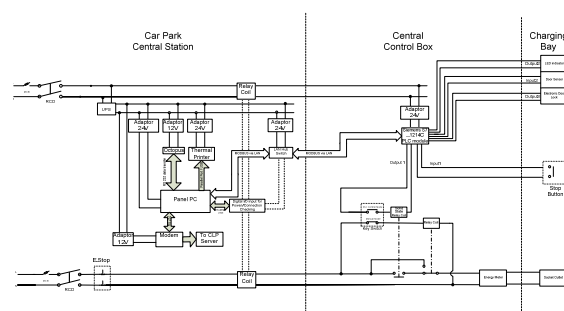

Figure 2: Schematic of the EV charging station system

The Charging Point is a metal box with cover which includes socket outlet, infra-red sensors and LED indicators. The Thin-Front-End design gives an aesthetic appearance and protects the plugged-in plug. It also facilitates workers for installation and number of Charging Points is scalable within the car park. However, locations

of Charging Points should be packed as a group in order to facilitate EV driver access easily to the Charging Kiosk for battery charging. Magnetic door lock has been implemented for further development which would adopt the RFID as keys for unlocking door.

The DSB control box consists of a number of individual control units. The number of control unit depends on the number of CPs. Each control unit is the linkage between the Kiosk and the CP. Firstly it waits for Kiosk query and reports the current status of the connected input. Secondly it performs control to the connected output when a command is received from the Kiosk. Each control unit consists of an energy meter and a digital input/output control module while both energy meter and control module were Ethernet-connected for identification.

Server for EV charging stations provides services of file transfer and time synchronization. Meanwhile, a secure transmission channel should be established between EV server and Kiosks to prevent from hacker attacks as service is opened for public. To achieve high security, each Kiosk is assigned a unique username and a password to log into server and access files from/to server. Dialing time, durations and rules has been set such that abnormal access could be traced. Except authorized password and username, another attribute that used in EV server is the caller-ID function. That is, only pre-defined phone number could get the server response when clients dial-up to server. To ensure Kiosk could perform schedule dialing, a time synchronization service is opened for Kiosk get the server local time.

2.3.2   Software

A control pilot program has been developed under Microsoft .NET framework to handle users, controller and server interfaces. Figure 3 & 4 shows the conceptual N-Tier architecture of the control pilot program and Main manual of the User-interface control pilot respectively. The control pilot program is designed in a way that any interface would work independently without affecting the others. The controller and server interfaces are working at the back-end simultaneously. Indeed, either one of the back tier stop working would not lead to the front end user-interface crash thus charging service is made available even the back end is totally fail to operate.
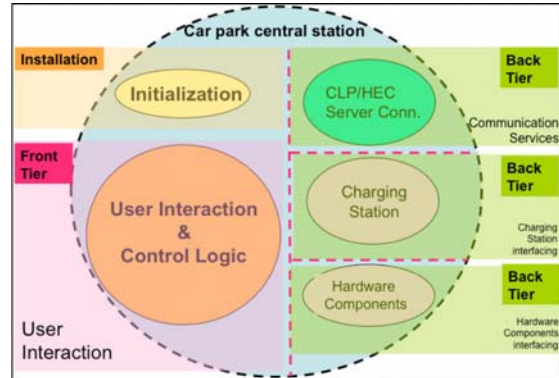

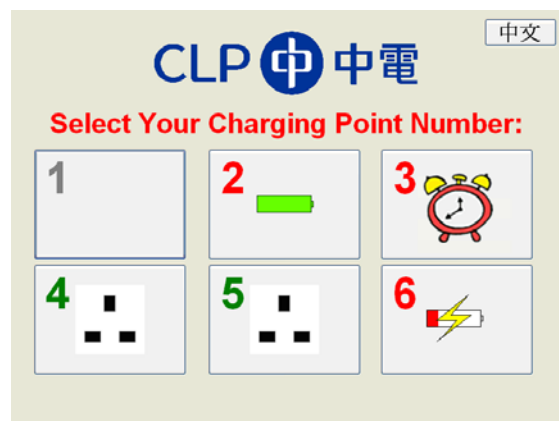Figure 3: Conceptual N-Tier software architecture (By courtesy of CLP)

Figure 4: Main manual of the control pilot program

Before control pilot program is initialized, configuration of the receipt details, tariff, number and name of CPs, authorized username and password could be set up through the configuration and account files. To prevent unused charging time is reset during power surge, status of CPs are recorded to files and stored in the Kiosk. When power resumed, control pilot program would check whether the corresponding CPs has unused charging time in initializing stage.

3   Charging Station Operation

To perform EV battery charging, users should first go to the CPs and plug-in. Two infra sensor are placed on the left and right sides on the socket outlet of the CPs for detecting the presence of the plug. Charging would only be allowed when plug present. Once the plug is plugged-in, users should then go to the Kiosk to select the corresponding charging bay. Charging bays are numbered or simply followed the car park numbering system which is configurable in control pilot program. Users can wipe their RFIDs after the charging

durations is selected and receipt would be printed after the transaction.

To terminate the power delivery, either charging time elapsed reaches zero seconds or sensors return no-plug message to Kiosk. i.e. the plug is unplugged. If the plug is dropped accidentally during charging process, power delivery stops immediately by the power switch in the DSP control unit. User could resume charging process if unused charging duration remains by RFID verification in case of accidental unplug. Such verification procedure could prevent CPs unauthorized usage and unknown user could not get power supplies without payment. Figure 5 shows the operation flow for a complete cycle of EV charging.
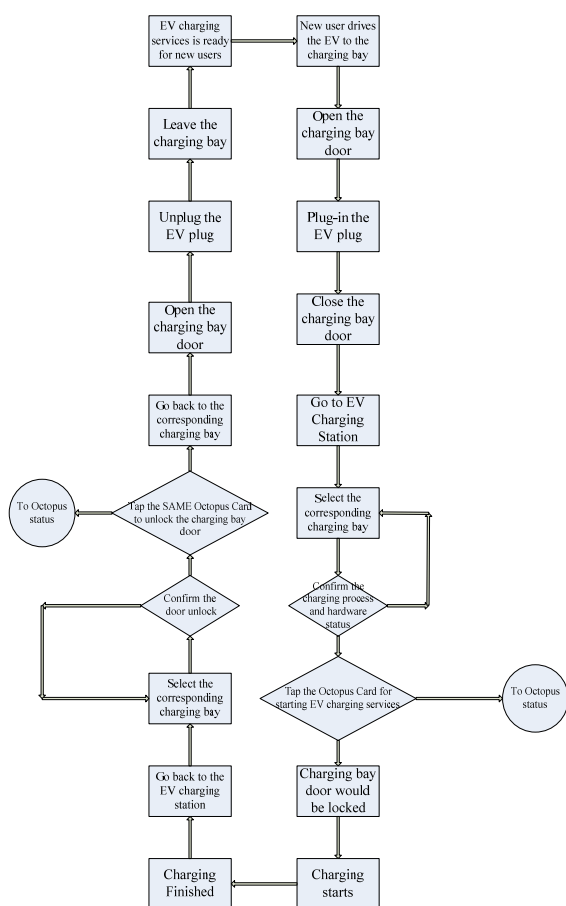

Figure 5: Operation Flow diagram for the charging process

At present, a total of number of 28 charging stations installed in Hong Kong, with over 50 CPs are grid-connected and ready to provide service. Figure 6 shows the distribution of Charging Kiosk available in Hong Kong.

Figure 6: Distribution of Charging Kiosk available in Hong Kong (By courtesy of CLP)

4   Conclusion

With the rising concerns and demands on EVs as an environmental-friendly alternatives in transportation to replace conventional fossil-fuel ones, different high capacity batteries adopting different topologies with long duty cycle, short charging time emerge. As the power electronics that used in the charging process would vary with different batteries to achieve the optimum performance, the charging network is built at the distribution level rather than the battery level at the moment. EV drivers would be benefited from less power electronics that would only be utilized during charging, if those power electronics converters could be provided in the charging system.

The present IEC 61851 standards for EV charging station still have room to be improved.[4] The communication protocol between the EV and the charging station would vary between different manufacturers. It is expected that a charging stations could deliver power to various EV while an EV would be compactable for different charging stations. Currently charging stations in Hong Kong at public places require electronic tariff payment for battery charging durations. Energy-based tariff payment would be an enhancement for the present versions of charging station.

Acknowledgments

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[4] IEC standard 61851, Electric Vehicle conductive charging system, part 1, 21 and 22

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