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Combined solution of V2G vehicle control circuit application for mass production EV

Kyoungjin Kim[1], Honggi Ko[2], Yongbok Lee[3]

[1] *Renault Samsung Motors, Republic of Korea, kyoungjin.kim@renaultsamsungM.com*

[2] *Techno Centre Renault, Guyancourt 78084, La République de France, honggi.ko@renault.com*

[3] *Renault Samsung Motors, Republic of Korea, yongbok.lee @renaultsamsungM.com*

Summary

In this paper, we describe specifications and design methods of V2G bi-directional charging circuit system on the mass product EV application. It is totally achieved from specific designed V2G charging system with high - speed communication controller unit and bi-directional charging module to past generation EV. V2G main purpose is grid communication between EV and infrastructure. It means EV can be used DER. V2G vehicle requires bi-directional charging system management and vehicle control. Our proposed idea provides combined solution for heterogeneous or different electric circuit integration and basic power electronics system to make V2G bi-directional reversable charging EV. Finally, Designed V2G code protocol is applied to the communication method and vehicle charging system control internally. It is evaluated charging power and V2G management.

Keywords: Communication Controller Unit, V2G, Combined, DER(Distributed Energy Resource), Bi-directional, Reversable, V2G code

1 Introduction

Recently, V2X bi-directional charging becomes to be a new energy resource and the replace solution for ESS secondary battery use. V2X use mainly EV Li-DC power battery. It needs to convert electric power to AC or lower DC power depend on “X” load connections. To supply energy to load, electric power system and Grid communications are required. For the power electronics, Bi-directional on-board charging system and controller are required. V2G communication needs high level protocol and control between physical charging system and electric architecture. It is required high speed and good performance controller to well manage existing vehicle charging system controller and V2G infrastructure.

V2G EV is developed by OEM, but legacy and before generation EV don’t have this system. So it is required high delivery cost.

In this paper, we propose special designed CCU (communication controller unit) and added V2G reverse charging module in on-board charging system. This communication controller integrates uni-direction

charging system and reverse charging system. Also, receive V2G grid code and send vehicle information to start charging or discharging.

1.1 V2G (Vehicle To Grid) Charging

V2G is simultaneously controls charging and discharging electric power of individual electric vehicle (EV) scattered all over the country according to signals of electric power network such as DR (Demand Response) or AGC (Automatic Generation Control). It is an integrated control device that makes batteries useful power resources. Also, their control protocol is considered ISO-15118, OCPP, equivalent protocol.

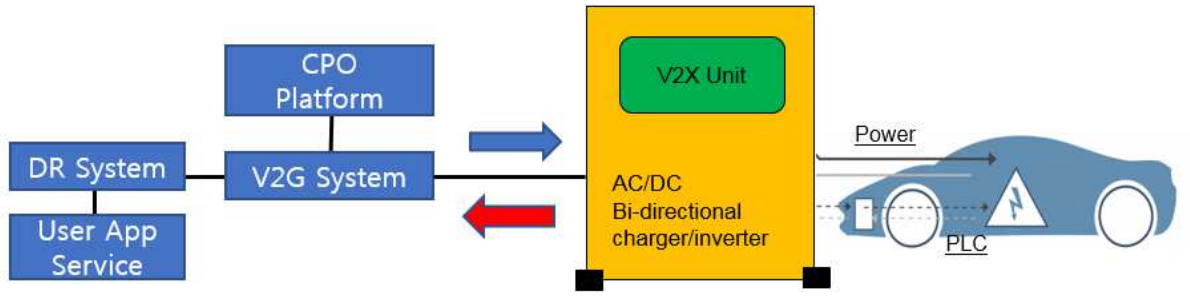

Figure1: V2G Infrastructure

1.2 V2G vehicle system

V2G vehicle level system is composed of below power electronics and vehicle controller with CAN, PLC communication. (Fig 2)

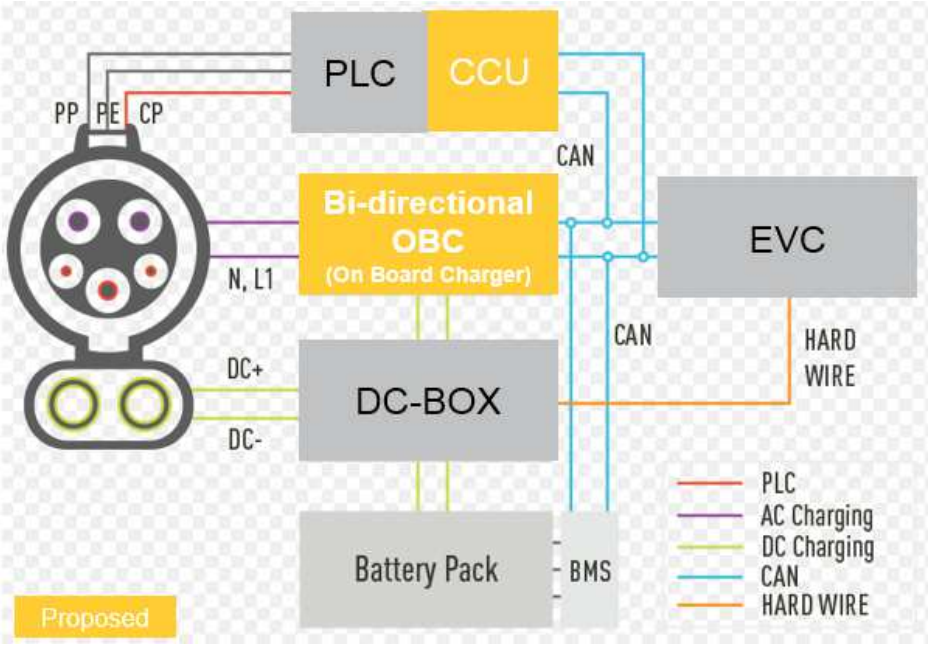

Figure2: Proposed V2G vehicle charging system application

To enable V2G function, it is required high performance level communication controller which involves V2G message processing to charge and discharge from grid requested by standard code. This request message is delivered by PLC (Power Line Communication, Home Plug Green PHY) from grid and CAN (Controller Area Network) to control vehicle internal system. Also, this message processing requires highly strong insulation and security which can prevent external hacking or noise. Yellow box is our designed idea. (Fig 2)

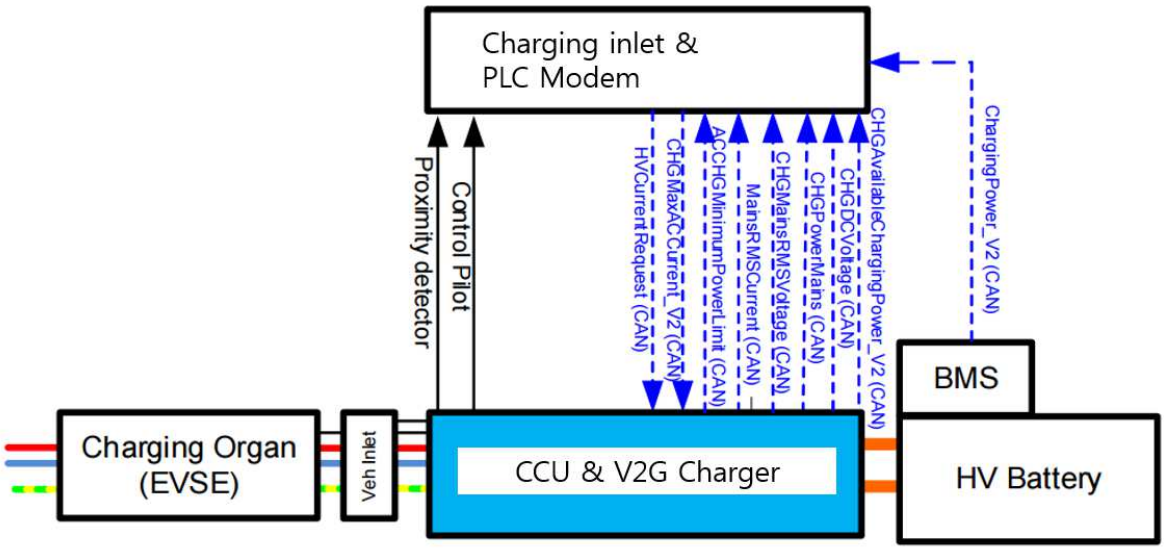

Figure3: Bi-directional charging system and control message

Normally, Uni-direction EV have OBC and basic level controller. We called that EVC (Electric Vehicle Controller) or VCU (Vehicle Control Unit). Also, This EV use CAN messages for internal charging system management.

This idea provided V2G charging solution, valuable communication controller and reverse charging module. This module is combined with existing normal direction OBC.

2 Communication Controller Unit

This unit is middleware device which provide communications between designed V2G OBC and circuit with V2X charger.

This CCU is controlled by ST dual MCU chip sets and support 4 x CAN ports, 12 V control, RJ45 with 10/100 Mbps ethernet communication, vehicle interlock check, voltage measure, current measure, and another device controlled by embedded S/W.

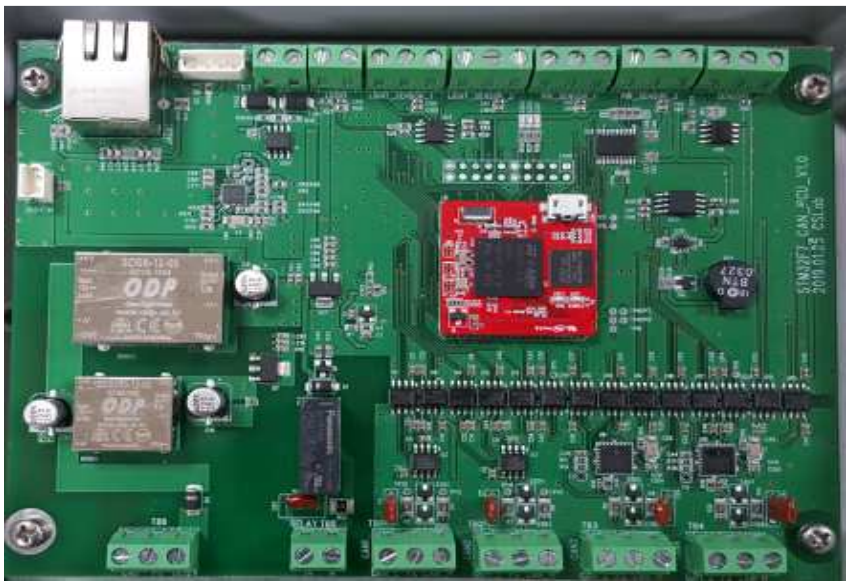

Figure 4: Communication Controller Unit

Also, this controller has below functions. We will more discuss.

2.1 V2G grid information transformation to EVC

To start V2G, Grid send grid code messages to vehicle. It contains CPO or grid management people information. Then, CCU receives this message and deliver it to vehicle controller. This CCU understand High level communication which is based on PLC with ISO-15118 road vehicle communication. This interface is an international standard. Also, CAN address exchange A and B channel for security.

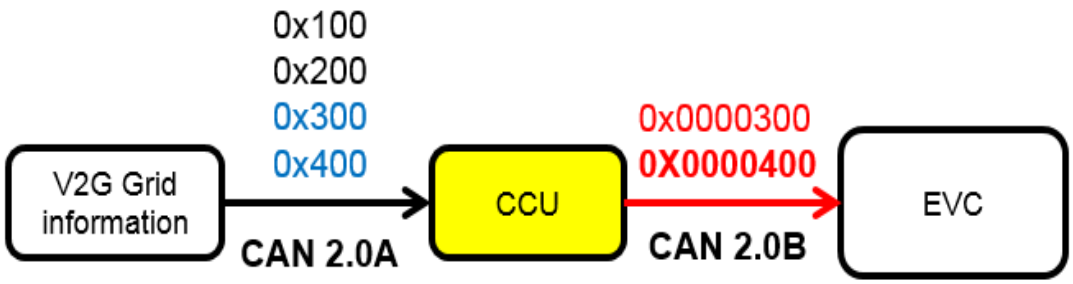

Figure 5: CAN data transfer

2.2 Isolation from Noise

To block external noise, this CCE use photo coupler. This is light-emitting element, and a light-receiving elements are optically coupled with each other for the purpose of transmitting an electric signal while electrically insulated between V2G power electronics system.

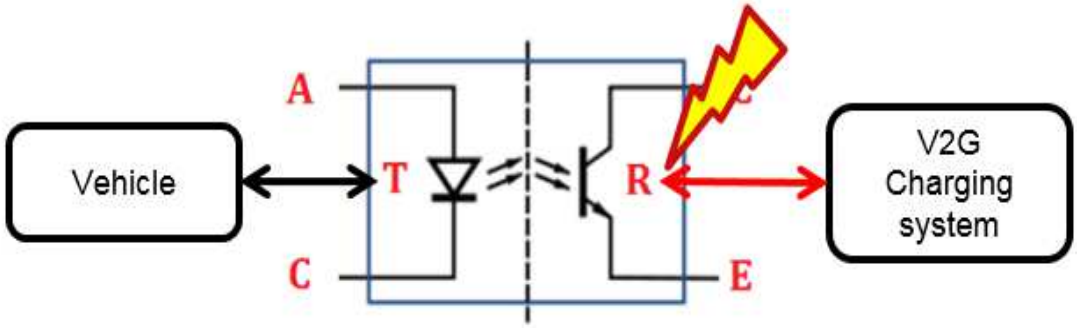

Figure 6: Photo coupler for isolation

2.3 Encryption messages

V2G charging normally do automatic charging. It is called PnC (Plug and Charge). It is requested between CPO, V2X charger and vehicle. To do this service, authentication to EV car is required. Because V2G gives benefit for CPO of energy sales or lower price time charging. It requests high level security from hacker or noise. This message is transferred TLS on the OSI 7 layer refer to ISO-15118. CCU provide this security with byte encryption to particular address. It can be changed to another value.

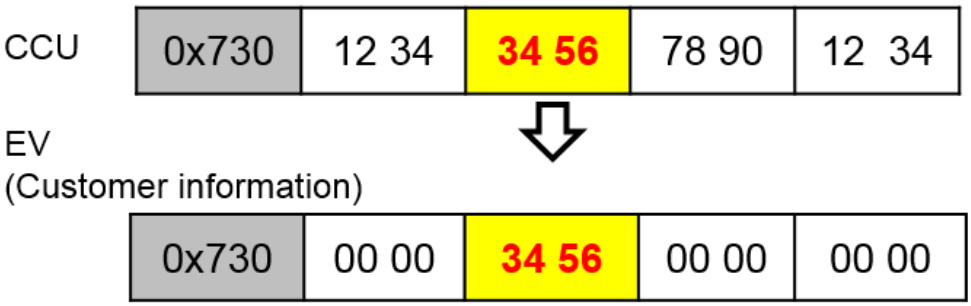

Figure 7: Message Encryption

2.4 Selective data permission

This designed architecture is integrating heterogeneous electric architecture to deliver all conditions. It means that selectively data process and vehicle control is required. This CCU does selectively transmission or pass specific data address.

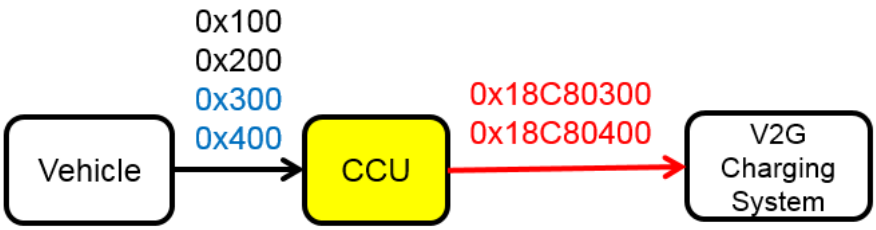

Figure 8: Data selection function

3 Reversable charging module

Main point of V2G is reverse flow energy to grid or X-Load. This energy transferred by AC or DC current. Our proposed idea is added DC reverse transfer module. This module is stacked on normal direction OBC.

This control is done by CCU. CCU select normal direction AC charging or DC reverse discharging refer to on demand charging request from user or CPO. The reverse flow discharging depends on high voltage battery capacity.

V2G charging or discharging requires fast response of grid or user request. It means that charging or discharging is changed dynamically.

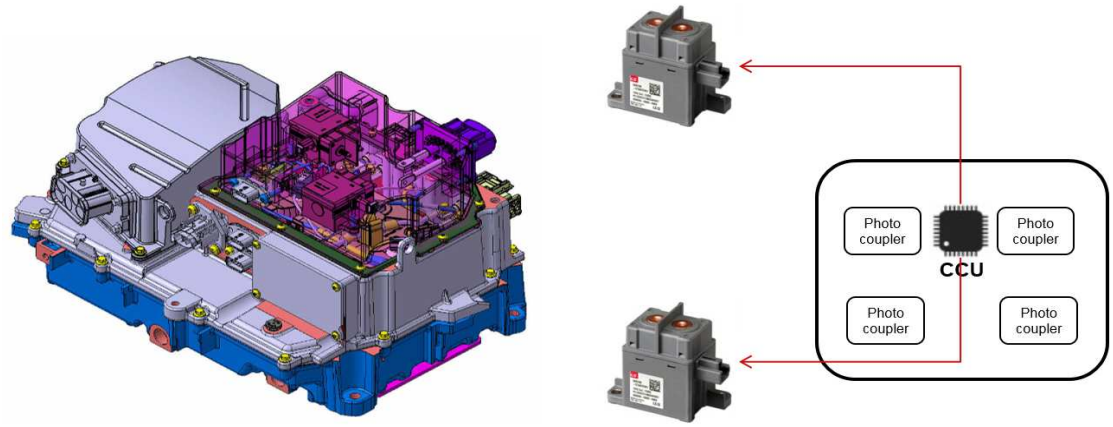

Figure 9: Reversable charging module

This reverse discharging module use 2 relays for DC discharging. CCU can operate discharging power relays quickly and safely.

4 V2G control parameter

To do V2G function operating, control protocol between V2X grid and EVC is required. To discharge, grid send discharging request to EV. Then EV acknowledge the required power. Our proposed CCU do this work reliable and fast. Table 1 represents V2G discharging parameter and response time. Also CCU control and reverse charging module together.

Parameter	Source	Response time (ms)	Unit
Discharging request	Grid	100	
Discharging Max current	Grid	100	A
Discharging Min Power	V2G EV	100	kW
Discharging Mains current	V2G EV	100	A
Discharging Mains Voltage	V2G EV	100	V
Discharging Mains power	V2G EV	100	kW
Discharging DC Voltage	V2G EV	100	V

Available discharging power	V2G EV	100	kW
BMS Charging power	V2G EV	100	kW

Table 1: V2G control protocol

5 Evaluations

To evaluate our proposed CCU and system, we compared charging performance of normal direction and reverse direction. We applied this system on mass production EV. Mass production EV is Renault Fluence ZE. This EV has 22 kW HV battery and using Max AC 3 Phase 43 kW Type 2 Chameleon Charging. Chameleon charging can charge 2 ~ 43 kW selectively refer to PWM. Our validation used Max 22 kW charging power for normal direction and reverse flow. Table 2 is the test specifications.

	Normal direction charging	Reverse Charging
Input power	3 Phase AC 380 V, 43 kW	NA
Output power	DC 100 ~ 400 V/110 A, 43 kW	DC 100 ~ 400 V/55 A, 22 kW
Output DC Voltage accuracy	± 3 V	± 3 V
Output Current accuracy	± 3 A	± 3 A
Power factor/Efficiency	0.98 / Over 90 %	0.98 / Over 90 %
Isolation impedance	10 MΩ @ 500 V	10 MΩ @ 500 V
Operation Temp range	- 20 ~ 35°C, Validated	- 20 ~ 35°C, Validated
Communication standard	SAE J1772/IEC 62196	ISO-15118

Table 2: Evaluation conditions

5.1 Bi-directional charging performance

Fig 10 shows normal direction charging and reverse flow charging. We compared similar SOC level increase for charging and decrease for reverse charging. We charged 20 % to 80 % and discharged 80 % to 20 %. To discharge, we used special DC load. Also, to operate reverse flow charging, we used CCU control and Vector CAN configuration instead of vehicle control. Because V2G charging is on developing today and related standards are creating by standard associations.

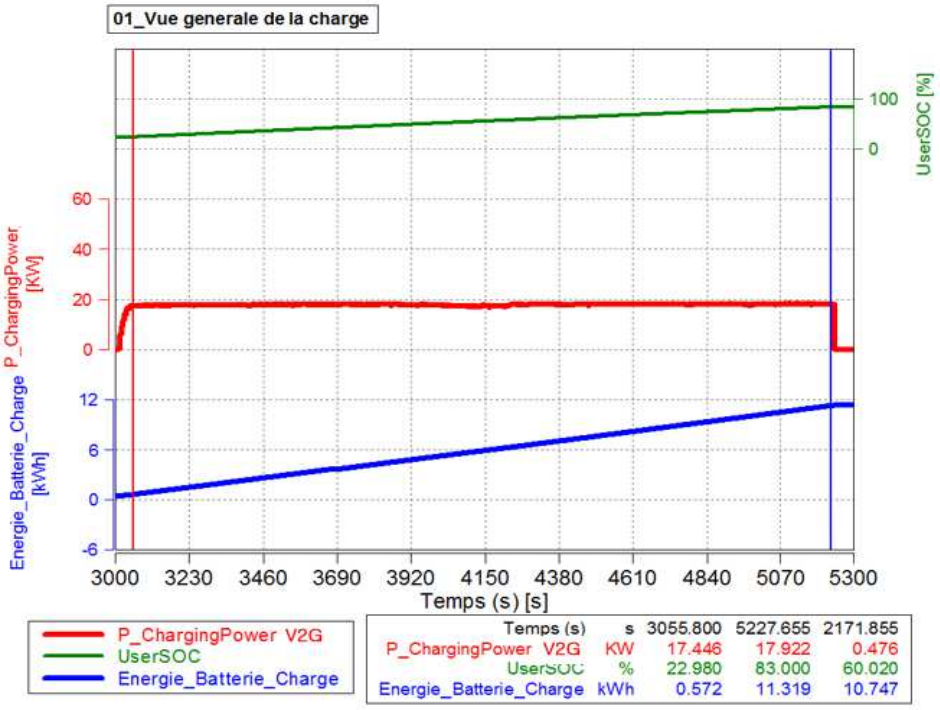

Figure 10: Charging, discharging current

CCU control is stable within ±1 kW different power level. It means that CCU is well controlled reverse charging module and understand V2G profile. It can continuously 22 kW discharge to V2X load. It means we can use EV battery power for home energy or DC electric device, and appliances.

5.2 Reverse Charging voltage and current

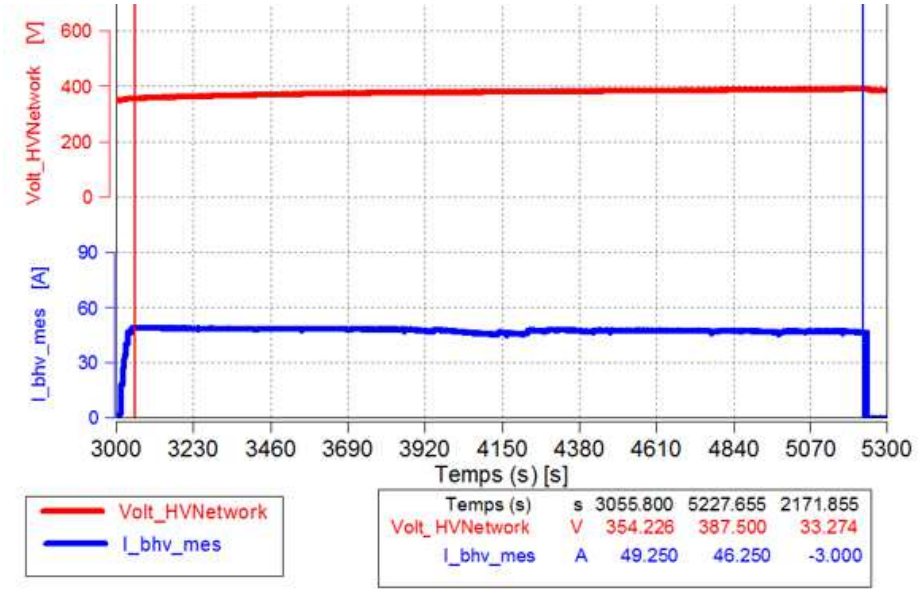

Figure 11: Charging power evaluation

This performance graph shows battery voltage and reverse charging current while reverse flow energy delivered. Even battery voltage is little fluctuation, current tolerance is within ±3 A. It means that this CCU controller delivers reverse DC power stable and reverse charging module is well operating.

6 Acknowledgments

We proposed V2G bi-directional charging solution and system application. This total system is combined legacy normal charging system and reverse energy flow function. It means that past generation EV can be energy trading work refer to CPO or grid demand request with our proposed system application. To make it more realistic, we developed CCU(Communication Controller Unit) to integrate heterogeneous electric circuits and charging system. Moreover, we combined developed DC reversable charging module box to provide reverse charging function. Finally, discharging method can be changed to DC or AC power with converter at the end of DC reverse module.

Finally, we tested bi-directional charging, discharging performance refer to DR's SOC with CCU regulations. The result shows stable charging in both directional charging.

To make final V2G EV mass production and industrialized model, V2X charging infrastructure and back-end service with security encryption are required. It called smart charging. Our proposed model will be more optimized and improved with V2G standard and grid integration, vehicle demonstration work.

7 Referencing

[1] SAE, "SAE J1772, SAE Electric vehicle and Plug in Hybrid Electric Vehicle Conductive Charger Coupler," 2016.

[2] IEC, "IEC 61851-1, Electric vehicle conductive charging system – Part 1: General requirements," ed 3.0., 2010.

[3] ISO 15118 Road vehicles -- Vehicle to grid communication interface is an international standard defining a vehicle to grid (V2G) communication interface for bi-directional charging/discharging of electric vehicles.

[4] Reanault EV-Ready Mark Certification DK 1.4 2017

[5] A Study on Precision Driving Technology using Magnet", 2017 ICEAS, 2017.7

[6] DIN SPEC 70121, Electromobility - Digital communication between a d.c. EV charging station and an electric vehicle for control of d.c. charging in the Combined Charging System

[7] KEPCO, "V-Grid Integration (VGI) and control technology development", KETP V2G project

[8] Renault, " R-N Specification V2G OBC design", 2018

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Authors

Kyoungjin Kim received M.S degree Information Technology & Telecomm Telecommunications Engineering from Inha University in 2004, Since 2004, he had been with Korea GM, where he was vehicle electric engineer. From 2010, he has been with Renault Samsung Motors. His current research interests are EV charging

Honggi Ko received B.S degree in Control & Instrumentation engineering from Kunsan National University in 2002, Since 2010, he had been with LS Cable, where he was EV charging system developer. From 2015, he has been with Renault Samsung Motors and Techno Centre Renault. His current research interests are system tuning and wireless power transfer vehicle.

Yong-bok LEE received M.S degree in Chemical Engineering from Pohang Science & Technology University in 1997. Since 2002, he has worked in Renault Samsung Motors, and he is leading E-powertrain team as a chief after 4 year's experience on EV project management as engineering leader.