5th International Electric Vehicle Technology Conference

EVTeC 2021

"Future mobility beyond CASE"

24-26 May 2021, Full online conference

Organized by Society of Automotive Engineers of Japan, Inc. (JSAE)

【Program】

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5th International Electric Vehicle Technology Conference

EVTeC 2021

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Contents

Welcome Remarks

EVTeC 2021

"Future Mobility beyond CASE"

Hiroshi Fujimoto
Chairperson of EVTeC 2021
The University of Tokyo

Organized by the JSAE, the leading academic society of automotive engineers in Japan, EVTeC is a conference that focuses on EVs, HEVs, FCVs, PHVs, and various other related technologies. The first EVTeC was held in May 2011 with great success. Despite being held just after the Great East Japan Earthquake, it featured the presentation of 66 papers and gathered 230 participants. The second EVTeC was successfully held in May 2014, featuring 90 papers and 264 participants. The third EVTeC was held in May 2016, which was also a success with 101 papers and 293 participants. The fourth was held jointly with EVS organized by JARI as EVS 31 & EVTeC 2018 in Kobe, October, resulting in the scale expansion of 317 papers and 1160 participants for the symposium.

The Technical Program Committee of EVTeC 2021 selected 90 papers worldwide among the submitted from 11 countries. The nine plenary talks, one keynote talk, 19 special sessions will give opportunities to have stimulating ideas on xEVs.

EVTeC 2021 was supposed to be held at Pacifico Yokohama, alongside the JSAE Annual Spring Congress. More than 90,000 people were expected to visit the exhibition. Participation in the Spring congress and exhibition is free of charge for EVTeC participants, and these events should have provided an excellent opportunity to see the forefront of activities being carried out in Japan.

Due to COVID-19 developments, the Japanese government declared a state of emergency for a pandemic in the greater Tokyo area on April 25th, and the on-site conference was canceled, unfortunately. As a result, EVTeC 2021 moved from hybrid to full online conference. Despite this drastic change-over and being no longer able to warmly welcome our authors and guests in person in Yokohama, all originally planned sessions of EVTeC 2021 have been converted into digital space.

Countries around the world are pinning much hope on electric vehicles and putting much effort into their popularization, as a means of dealing with global warming problems, extricating themselves from dependence on oil, and addressing energy conservation. As part of this, along with innovations in batteries and other component technologies, the evolution of EV bodies has been steadily promoted.

Furthermore, in recent years, in addition to partnerships with electric power systems, we have also begun exploring the potential for creating value and providing services based on new perspectives such as CASE (connected, autonomous, shared, and electric) on the back of advances in information technology.

It is our hope, therefore, that EVTeC 2021 will serve as a forum for international discussion on the topics of new mobility beyond CASE in the form of next-generation electric vehicles and smart society.

I would like to thank the volunteers who spent their time to bring EVTeC 2021 to you. Especially, we want to acknowledge the efforts of the Program Chairs, Technical Program Committee members, reviewers, the Special Sessions Chairs and Organizers, and all those persons in charge of all the conference-related activities, from local arrangements to the conference secretariat.

I hope that the conference will satisfy your highest intellectual and cultural expectations and wish you to enjoy all technical and social aspects of EVTeC 2021.

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Capacitors Forum (Japan)

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Plenary Session / Keynote Speech

May 24 (Mon.)

Plenary Session 1 **Room 1 (9:30-10:10)**

Moderator: Yoichi Hori (Tokyo University of Science)

Present Japanese automotive industry and future trends of xEV

Hiroki Aoki

Director, Automobile Division, Manufacturing Industries Bureau, Ministry of Economy, Trade and Industry

Plenary Session 2 **Room 1 (10:10-10:50)**

Moderator: Makoto Uchida (University of Yamanashi)

Hydrogen and Fuel Cell R&D in China

Jianbo Zhang

Director of the Automotive Engineering, School of Vehicle and Mobility, Tsinghua University

Plenary Session 3 **Room 1 (10:50-11:30)**

Moderator: Shigeharu Yamagami (Nissan Motor Co., Ltd.)

Vision of Achieving Carbon Neutrality in 2050

Keiji Ohtsu

President and Representative Director, Honda R&D Co., Ltd.

May 25 (Tue.)

Plenary Session 4 **Room 1 (9:30-10:10)**

Moderator: Yukio Yokoi (Takushoku University)

EV Wireless Charging: Global Update

David Schatz

Vice President of Sales & Business Development, WiTricity Corporation

Plenary Session 5 **Room 1 (10:10-10:50)**

Moderator: Hiroshi Fujimoto (The University of Tokyo)

GaN device as a key technology for realizing carbon neutral society

Hiroshi Amano

Institute of Materials and Systems for Sustainability, Nagoya University
The Nobel Prize in Physics 2014

Plenary Session 6 **Room 1 (10:50-11:30)**

Moderator: Jun-ichi Itoh (Nagaoka University of Technology)

Nissan's Challenges for Sustainable Society

Toshihiro Hirai

Senior vice president, Alliance SVP, Powertrain & EV Engineering Division, Nissan Motor Co., Ltd.

Plenary Session / Keynote Speech

May 26 (Wed.)

Plenary Session 7 **Room 1 (9:30-10:10)**

Moderator: Yoshitaka Asakura (AYE)

Introduction on Chinese Standards for Electric Vehicles

Guibin Liu

Chief Engineer of Automotive Standardization Research Institute (ASRI),
China Automotive Technology and Research Center Co., Ltd. (CATARC)

Plenary Session 8 **Room 1 (10:10-10:50)**

Moderator: Kan Akatsu (Yokohama National University)

Novel Stator-Excited Synchronous Machines without Rare-earth Magnets for Electric Vehicles

Zi-Qiang Zhu (Z.Q. Zhu)

Fellow of Royal Academy of Engineering, Fellow of IEEE and IET
Head of Electrical Machines and Drives Group, University of Sheffield

Plenary Session 9 **Room 1 (10:50-11:30)**

Moderator: Daichi Imamura (Japan Automobile Research Institute)

Transformation into a Mobility Company

Shigeki Terashi

Member of the Board of Directors, Executive Fellow
TOYOTA MOTOR CORPORATION

Keynote Speech **Room 1 (16:00-16:45)**

Moderator: Takashi Majima (IHI Inspection & Instrumentation Co., Ltd.)

Fair Competitions and Collaborations drive Innovation

Takafumi Anegawa

Fellow, Tokyo Electric Power Company Holdings, Inc.

EVTeC 2021 Timetable

May 24 (Mon.)

Room 1	Room 2	Room 3
9:20		
9:30	**Opening Ceremony (@Room 1)**	
10:10	**Plenary Session 1 (@Room 1)** **Hiroki Aoki (Ministry of Economy, Trade and Industry)** ***"Present Japanese automotive industry and future trends of xEV"*** Moderator: Yoichi Hori (Tokyo University of Science)	
10:50	**Plenary Session 2 (@Room 1)** **Jianbo Zhang (Tsinghua University)** ***"Hydrogen and Fuel Cell R&D in China"*** Moderator: Makoto Uchida (University of Yamanashi)	
11:30	**Plenary Session 3 (@Room 1)** **Keiji Ohtsu (Honda R&D Co., Ltd.)** ***"Vision of Achieving Carbon Neutrality in 2050"*** Moderator: Shigeharu Yamagami (Nissan Motor Co., Ltd.)	
12:30	Break	
14:10	**A1 (Special Session)** **Traction Motor for Evs** **20214279 / A1.1** **20214280 / A1.2** **20214281 / A1.3** **20214282 / A1.4** Chairs: Hiroya Sugimoto (Tokyo Denki University) Kan Akatsu (Yokohama National University)	**B1 (Special Session)** **Fuel Cell System and Vehicle** **20214292 / B1.1** **20214293 / B1.2** **20214294 / B1.3** **20214295 / B1.4** Chairs: Yoshiyuki Hashimasa (Japan Automobile Research Institute) Hitoshi Igarashi (Volkswagen Group Japan KK)	**C1 (Special Session)** **Cutting Edge of xEV System** **20214304 / C1.1** **20214305 / C1.2** **20214306 / C1.3** **20214307 / C1.4** **20214308 / C1.5** Chairs: Eiji Kuroda (Japan Automobile Research Institute) Jon Are Suul (Sintef Energy Research / Norwegian University of Science and Technology)
14:25	Break	
16:05	**A2 (Special Session)** **Advanced Drive Technologies for Electric Machines** **20214283 / A2.1** **20214284 / A2.2** **20214285 / A2.3** **20214286 / A2.4** **20214287 / A2.5** Chairs: Kyohei Kiyota (Tokyo Institute of Technology) Hideaki Arita (Mitsubishi Electric Corporation)	**B2 (Special Session)** **Fuel Cell Stack and Components** **20214296 / B2.1** **20214297 / B2.2** **20214298 / B2.3** **20214299 / B2.4** **20214300 / B2.5** Chairs: Akihiro Iiyama (University of Yamanashi) Kenichiro Ota (Fuel Cell Development Information Center)	**C2 (Special Session)** **Connected and Autonomous Technologies on Next Generation xEV** **20214309 / C2.1** **20214310 / C2.2** **20214311 / C2.3** Chairs: Takeshi Kato (Honda R&D Co.Ltd) Valentin Ivanov (Technische Universität Ilmenau)
16:20	Break	
18:00	**A3** **Structure and Control of Electric Machines** **20214288 / A3.1** **20214289 / A3.2** **20214290 / A3.3** **20214291 / A3.4** Chairs: Junichi Asama (Shizuoka University) Hiroki Goto (Utsunomiya University)	**B3 (Special Session)** **Power Electronics Components** **20214301 / B3.1** **20214302 / B3.2** **20214303 / B3.3** Chairs: Kenta Emori (Nissan Motor Co., Ltd.) Kraisorn Throngnumchai (Kanagawa Institute of Technology)	**C3 (Special Session)** **Advanced xEV Motion Control & Dynamics** **20214312 / C3.1** **20214313 / C3.2** **20214314 / C3.3** **20214315 / C3.4** **20214316 / C3.5** Chairs: Hiroshi Fujimoto (The University of Tokyo) Husam Muslim (Japan Automobile Research Institution / University of Tsukuba)

May 25 (Tue.)

Room 1	Room 2	Room 3
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9:30		
10:10	**Plenary Session 4 (@Room 1)** **David Schatz (WiTricity Corporation)** ***"Global Progress of Wireless Charging for Passenger and Commercial Vehicles"*** Moderator: Yukio Yokoi (Takushoku University)	
10:50	**Plenary Session 5 (@Room 1)** **Hiroshi Amano (Nagoya University)** ***"GaN device as a key technology for realizing carbon neutral society"*** Moderator: Hiroshi Fujimoto (The University of Tokyo)	
11:30	**Plenary Session 6 (@Room 1)** **Toshihiro Hirai (Nissan Motor Co., Ltd.)** ***"Nissan's Challenges for Sustainable Society"*** Moderator: Jun-ichi Itoh (Nagaoka University of Technology)	
12:30	Break	
14:10	**D1 (Special Session)** **Wireless Power Transfer I** **20214317 / D1.1** **20214318 / D1.2** **20214319 / D1.3** **20214320 / D1.4** **20214321 / D1.5** Chairs: Takashi Hikage (Hokkaido University) Yukio Yokoi (Takushoku University)	**E1 (Special Session)** **Energy Storage Devices & Systems I** **Next-Generation Batteries and Capacitors** **20214327 / E1.1** **20214328 / E1.2** **20214329 / E1.3** **20214330 / E1.4** Chairs: Chihiro Yada (TOYOTA MOTOR CORPORATION) Hiroyuki Akashi (Envision AESC Japan Ltd.)	**F1** **Safety and Security for E-mobility and Infrastructure** **20214338 / F1.1** **20214339 / F1.2** **20214340 / F1.3** Chairs: Yasuo Matsunaga (Nissan Motor Co., Ltd.) Takahiro Noyori (AVL JAPAN)
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16:05	**D2 (Special Session)** **Wireless Power Transfer II** **20214322 / D2.1** **20214323 / D2.2** **20214324 / D2.3** **20214325 / D2.4** **20214326 / D2.5** Chairs: Katsuhiro Hata (The University of Tokyo) Takashi Ohira (Toyohashi University of Technology)	**E2 (Special Session)** **Energy Storage Devices & Systems II** **Systems and Applications** **20214331 / E2.1** **20214332 / E2.2** **20214333 / E2.3** **20214334 / E2.4** Chairs: Kenji Natori (Chiba University) Noriko Yoshizawa (National Institute of Advanced Industrial Science and Technology (AIST))	**F2 (Special Session)** **Design, Evaluation and Related Technologies for Vehicles** **20214341 / F2.1** **20214342 / F2.2** **20214343 / F2.3** **20214344 / F2.4** Chairs: Yoshitaka Asakura (AYE) Daisuke Gunji (NSK Ltd.)
16:20	Break	
18:00		**E3 (Special Session)** **Energy Storage Devices & Systems III** **Lithium-ion Battery Technologies** **20214335 / E3.1** **20214336 / E3.2** **20214337 / E3.3** Chairs: Daichi Imamura (Japan Automobile Research Institute) Kazuhiro Sakuma (Materials Innovation Tsukuba, Inc.)	**F3 (Special Session)** **Energy Transmission Systems to Vehicles and Global Warming I** **20214345 / F3.1** **20214346 / F3.2** **20214348 / F3.3** **20214349 / F3.4** Chairs: Osamu Shimizu (The University of Tokyo) Kenji Morita (Japan Automobile Research Institute)

May 26 (Wed.)

Room 1	Room 2	Room 3
9:20		
9:30		
10:10	**Plenary Session 7 (@Room 1)** **Guibin Liu (CATARC)** ***"Introduction on Chinese Standards for Electric Vehicles"*** Moderator: Yoshitaka Asakura (AYE)	
10:50	**Plenary Session 8 (@Room 1)** **Zi-Qiang Zhu (Z.Q. Zhu) (University of Sheffield)** ***"Novel Stator-Excited Synchronous Machines without Rare-earth Magnets for Electric Vehicles"*** Moderator: Kan Akatsu (Yokohama National University)	
11:30	**Plenary Session 9 (@Room 1)** **Shigeki Terashi (TOYOTA MOTOR CORPORATION)** ***"Transformation into a Mobility Company"*** Moderator: Daichi Imamura (Japan Automobile Research Institute)	
12:30	Break	
14:10	**G1 (Special Session)** **Wireless Power Transfer III** **20214350 / G1.1** **20214353 / G1.2** **20214352 / G1.3** **20214351 / G1.4** Chairs: Ryosuke Ota (Tokyo University of Science) Keisuke Kusaka (Nagaoka University of Technology)	**H1 (Special Session)** **Power Electronics Component and System Technologies** **20214358 / H1.1** **20214359 / H1.2** **20214360 / H1.3** Chairs: Hiromichi Imai (Honda Motor Co., Ltd.) Satoshi Yasuda (TOYOTA MOTOR COPORATION)	**I1** **Energy Transmission Systems to Vehicles and Global Warming II** **20214365 / I1.1** **20214366 / I1.2** **20214367 / I1.3** **20214368 / I1.4** **20214369 / I1.5** Chairs: Yutaka Ota (Osaka University) Nobunori Okui (National Traffic Safety and Environment Laboratory)
14:25	Break	
16:00	**G2 (Special Session)** **Wireless Power Transfer IV** **20214354 / G2.1** **20214357 / G2.2** **20214355 / G2.3** **20214356 / G2.4** Chairs: Naoki Shinohara (Kyoto University) Giuseppe Guidi (Sintef Energy Research)	**H2 (Special Session)** **Power Semiconductor and Packaging Technologies** **20214361 / H2.1** **20214362 / H2.2** **20214363 / H2.3** **20214364 / H2.4** Chairs: Shigeharu Yamagami (Nissan Motor Co., Ltd.) Michiaki Hiyoshi (Hyundai Motor Japan R&D Center, Inc.)	
16:00	Break	
16:45	**Keynote Speech (@Room 1)** **Takafumi Anegawa** **(Tokyo Electric Power Company Holdings, Inc.)** ***"Fair Competitions and Collaborations drive Innovation"*** Moderator: Takashi Majima (IHI Inspection & Instrumentation Co., Ltd.)		
17:05	**Awards & Closing Ceremony (@Room 1)**		
17:40			

Session Schedule

May 24 (Mon.)

A1 (Special Session): Traction Motor for Evs **Room 1 (12:30-13:50)**

Chairs: Hiroya Sugimoto (Tokyo Denki University)
Kan Akatsu (Yokohama National University)

20214279 **Development of Noise and Vibration Reduction for the Driving Motor in Electric Vehicles**
A1.1 *Suguru Gangi, Naoto Koshino, Hiroaki Ebuchi, Keiji Takizawa, Ryoji Sato (TOYOTA MOTOR CORPORATION)*

Abstract:

In order to deal with recent environmental issues and energy saving, we have commercialized HVs and EVs. One of the features of electric vehicles is quietness due to engine stop / less. On the other hand, it is easy to hear the activating noise of the electric powertrain unit including the motor which is not installed in conventional cars. In addition, FR vehicles are generally often set to luxury cars, and it is required for them to have better quietness. Therefore, reducing motor noise in the transmission is a particularly important issue in FR EHVs vehicles. This paper describes some hardware- and software-based countermeasures to the electromagnetic noise due to activation of the motor.

20214280 **Development of high efficiency low noise electric motor for electrified vehicle**
A1.2 *Akihiro Tanaka[1], Toru Nakada[1], Katsumi Yamazaki[2] ([1]Nissan Motor Co., Ltd., [2]Chiba Institute of Technology)*

Abstract:

This paper describes the newly developed electric motor for the new Nissan NOTE e-POWER. NOTE e-POWER is a series hybrid vehicle that was launched in 2016. This vehicle achieved quick acceleration, quietness, and good fuel efficiency owing to the electric motor that contributes to the global driving force. The electric motor, which in the conventional NOTE e-POWER was a carry-over part from an EV, will be a newly developed high competitive innovation in regards to compactness, cost, efficiency and NVH performances and will be applied in the new NOTE e-POWER.

20214281 **Development of e-Axle with High-Power-Density PM Motor**
A1.3 *Kiyoshi Uemura, Hiroaki Yoshida, Junichi Aoki, Tadashi Ashikaga, Yoshinori Nakano (MEIDENSHA CORPORATION)*

Abstract:

As a recent trend of the EV drive system, the development of e-Axles with the motor, inverter, and transaxle integrated into a single device is activated. We have developed an e-Axle with the height reduced by our specific configuration in consideration of such conditions as vehicle mounting requirements. We would like to introduce below our recently developed prototype.

20214282 **Development of a Dual-mode Reluctance Motor for Electric Vehicle Applications**
A1.4 *Kyohei Kiyota[1], Haruka Isogai[2], Kenji Amei[2], Takahisa Ohji[2], Akira Chiba[1] ([1]Tokyo Institute of Technology, [2]University of Toyama)*

Abstract:

This paper proposes a novel Dual-mode Reluctance Motor which can switch the motor mode between a switched reluctance motor and a synchronous reluctance motor to enhance the high efficiency region. The efficiency of a synchronous reluctance motor mode is high with respect to that of a switched reluctance motor mode in higher rotational speed and low power region because of the lower iron loss specification of the synchronous reluctance motor. In this paper, the verification of the proposed method using the fabricated DRM is carried out.

A2 (Special Session): Advanced Drive Technologies for Electric Machines **Room 1 (14:25-16:05)**

Chairs: Kyohei Kiyota (Tokyo Institute of Technology)
Hideaki Arita (Mitsubishi Electric Corporation)

20214283 **Flattening Radial Force Sum Method for Noise Reduction in Traction Switched Reluctance Motor**
A2.1 *Candra Adi Wiguna, Lim Li Sing Sarah Lilian, Akira Chiba (Tokyo Institute of Technology)*

Abstract:

This paper presents the effectiveness of the radial force sum flattening method to reduce the acoustic noise of the switched reluctance motor for the traction applications. The proposed current is compared to the conventional square current, typical current for switched reluctance motor. The analysis shows that the radial force sum of the proposed current has lower variation than the radial force sum of the conventional square current. The effectiveness of the radial force sum flattening method is verified by the experiments. The experiments were carried out from 500 rpm to 3000 rpm in the constant average torque of 10 Nm. The experimental result shows that the peak noises at the multiple of 3rd of current harmonics are reduced by the proposed current. The highest peak at 2800 rpm, 1689 Hz is reduced by 38.5 dB.

20214284 **Torque Ripple Reduction Control of Switched Reluctance Motor with Operating Area Expandable Drive Circuit**
A2.2 *Hiroki Goto, Yuki Matsumoto, Taisei Kurishima, Ryohei Ebata, Hirohito Funato, Junnosuke Haruna (Utsunomiya University)*

Abstract:

A novel drive circuit of switched reluctance motors, which can boost phase voltages without external inductors, have been proposed in previous works. In this paper, the simulation results which the proposed drive circuit is applied to an in-wheel direct-drive electric vehicle with low voltage batteries are shown. The simulation results show that the proposed drive circuit can expand the operational area drastically and the proposed control method can reduce torque ripple at all operational range.

20214285 **Temperature Visualization of Motor Using Wireless Sensing During Vehicle Running**
A2.3 *Tatsuo Nishimura[1], Yuki Hidaka[1], Kazuya Itoh[2], Osamu Nasu[1], Kenji Kato[1], Hideaki Arita[1], Kazumasa Ito[1] ([1]Mitsubishi Electric Corporation, [2]National Institute of Technology)*

Abstract:

In a vehicle, factors, such as ambient temperature and transient phenomena, can cause disparities in motor performance in terms of motor units and vehicle operation, especially with regard to temperature characteristics. This paper presents a digital twin-oriented solution to visualize temperature distribution inside a motor while the vehicle is running. We placed thermal sensors inside a motor and built a Bluetooth communication network to visualize the temperature conditions inside the motor for external monitoring, even when the actual vehicle is running. In this paper, we describe the structure of the motor being measured and provide an overview of how wireless communication is used. We also report the results of installing each component in a compact vehicle and the temperature distribution in the motor while the vehicle is running.

20214286 **Fault Tolerant Asymmetrical Six Phase Drive Controlled by Two Microprocessors**
A2.4 *Shen Wang[1], Kentaro Kitamura[1], Shinji Doki[1], Takashi Suzuki[1], Kiyoshi Fujii[2], Norihisa Ito[2], Yoshitaka Hayashi[2] ([1]Nagoya University, [2]DENSO CORPORATION)*

Abstract:

In order to decrease air pollutant emissions, Electric Vehicles (EVs) have gained worldwide attentions and got popularized in an increasing speed. Motor drives power the EV including propulsion and auxiliary component such as power steering. Conventional three phase drives have been most widely adopted due to mature industrial standards and fair performance. Nevertheless, multiphase machines have become alternatives because they have beneficial characteristics such as great potential in fault tolerance and higher reliability. Thereby, this paper focuses on an asymmetrical six-phase drive, specifically equipped with 2 separate microprocessors for two sub-winding system. The two microprocessors provide integrated fault tolerance of the drive. Moreover, a novel current vector control scheme that utilizes observer to estimate the subsystem current for interference compensation against the magnetic winding sets has been proposed for its control.

20214287 **Sensorless brushless motor start ability improvement by estimating initial position**
A2.5 *Naoki Onosaka, Takeru Yamamoto (AISIN SEIKI Co., Ltd.)*

Abstract:

The main issue is deterioration of motor N/V performance caused by supply current distortion in sensorless brushless DC motor start. Therefore the main purpose in this study is to reduce supply current distortion and to achieve reduction, estimation of rotor initial position is examined without adding additional hardware such as sensors. The conclusion is that estimation of rotor initial position within four quadrant range is succeeded by changing software only and supply current distortion and convergent time are reduced by changing direction of single phase excitation according to initial position.

A3: Structure and Control of Electric Machines — Room 1 (16:20-17:40)

Chairs: Junichi Asama (Shizuoka University)
Hiroki Goto (Utsunomiya University)

20214288 **Development of High-Speed Motor with a Welding-Less Coil and High- Strength Rotor**
A3.1 *Masanori Sawahata, Masahiro Hori, Takafumi Hara, Minori Nagata, Yuji Enomoto (Hitachi, Ltd.)*

Abstract:

We have developed the high-speed permanent magnet synchronous motor (PMSM) with a maximum rotation speed of 22,000 min^{-1}, which enables the motor to be downsized. This PMSM is applied to a welding-less coil to shorten the axial motor length and a robust rotor structure to achieve high rotor strength. Elemental tests and measurements demonstrate that (i) the rotor does not deform under high rotation speed and (ii) the torque and coil temperature of the developed PMSM reach their design values.

20214289 **Pulse Injection and Rotation Characteristics of 1 kW-class AlNiCo Magnet Assisted Switched Reluctance Motor**
A3.2 *Yuki Okamoto[1], Taketsune Nakamura[1], Fuat Kucuk[1,2] ([1]Kyoto University, [2]Kyoto University of Advanced Science)*

Abstract:

This paper reports preliminary test results of pulse injection and load characteristics of a 1 kW-class permanent magnet assisted switched reluctance motor, in which AlNiCo magnets are situated in the back yoke of a stator core. The stator and rotor have 6 and 4 salient poles, respectively. The AlNiCo magnets change their magnetizing amount by the pulse current applied from the stator winding. It is shown that the AlNiCo magnets are successfully magnetized by using the capacitor circuit. Furthermore, the fabricated motor is successfully loaded at 1 kW rated power at 1600 rpm and its corresponding efficiency is 89.2% without any optimization. The results of this study suggest the possibility of variable magnetic flux technology for switched reluctance motors.

20214290 **A Drive System with Low Noise and Vibration for a High-speed PMSM**
A3.3 *Takafumi Hara[1], Takaya Tsukagoshi[2], Masanori Sawahata[1], Masahiro Hori[1], Toshiyuki Ajima[1], Takaki Itaya[2], Katsuhiro Hoshino[2], Noriyuki Maekawa[2] ([1]Hitachi, Ltd., [2]Hitachi Astemo, Ltd.)*

Abstract:

A motor drive system for driving a high-speed permanent magnet synchronous motor (PMSM) at a maximum rotation speed of 22,000 rev/min was developed and experimentally verified. Synchronous PWM control is applied to this PMSM to achieve stable drive at high speed. Moreover, a control scheme called “carrier-shift control” for reducing torque ripple was also developed. This scheme matches ripple frequencies caused by spatial and time harmonics. The ripple caused by space harmonics is canceled by the ripple caused by time harmonics on the basis of the phase shift of the carrier wave. The developed motor drive system was verified experimentally, and the results reveal that the developed control scheme reduces low-frequency ripple and vibration at 19,500 rev/min.

20214291 **Online Derivation of Control Parameters by Strength Pareto Evolutionary Algorithm 2 for Vibration Reduction in**
A3.4 **SRM**
Kohei Umeta, Nobukazu Hoshi, Ryosuke Ota (Tokyo University of Science)

Abstract:

Switched reluctance motor (SRM) suffers from large vibration. However, it is difficult to derive the optimum control parameters to reduce the vibration. As a solution to the problem, this paper proposes a method that uses Strength Pareto Evolutionary Algorithm 2 (SPEA2). In the proposed method, the optimum control parameters for each torque can be derived online. In this paper, the effectiveness of the method was confirmed with a simulation and an experiment. In the simulation, it could be confirmed that the radial force, which was one of the causes of the vibration, was reduced with the proposed method. The noise reduction by the method was also confirmed in the experiment.

B1 (Special Session): Fuel Cell System and Vehicle — Room 2 (12:30-13:50)

Chairs: Yoshiyuki Hashimasa (Japan Automobile Research Institute)
Hitoshi Igarashi (Volkswagen Group Japan KK)

20214292 **Development of New Fuel Cell System**
B1.1 **- Fuel Cell System for the New Mirai -**
Tsuyoshi Takahashi, Yuji Kakeno (TOYOTA MOTOR CORPORATION)

Abstract:

Countries around the world are beginning to aim for carbon neutrality as a solution for global warming. Hydrogen is a clean energy that will play an important role in realizing this objective. In 2014, Toyota Motor Corporation launched the first-generation Mirai equipped with a mass-production fuel cell system (called the Toyota Fuel Cell System, or TFCS) to help promote the use of hydrogen. The completely redesigned second-generation Mirai was launched in 2020 with the mission of providing a starting point toward the realization of a hydrogen energy-based society. This paper introduces the technical challenges of the second-generation TFCS installed in the new Mirai, which was designed to help achieve the full-scale popularization of hydrogen energy.

20214293 **Application of Model Based Development to Product Fuel Cell Systems and Controller Design**
B1.2 **- Physical Modeling of the Entire Fuel Cell System and Implementation to Controller -**
Shigeki Hasegawa[1], Jared Farnsworth[2], Motoyuki Kimata[1], Naoki Tomi[1,] Nobukazu Mizuno[1], Daniel Folick[2], Kentaro Fukuda[3], Andrew Sata[2], Miho Hatazaki[4], Yoshihiro Ikogi[1] ([1]TOYOTA MOTOR CORPORATION, [2]TOYOTA MOTOR NORTH AMERICA, [3]DENSO CORPORATION, [4]SOKEN, INC.)

Abstract:

1-dimentional (1D) physical modeling methods of fuel cell stack and balance of plants (air-supply system, H2-supply system and cooling system) are investigated. To ensure simulation of life-long system operation in permissible calculation time and accuracy, proper resolution of modeling methods is chosen and in-house high-speed numerical solvers are developed. This model is validated and verified by actual fuel cell system data gathered in a variety of operating conditions (low to high loads, operating temperatures and ambient pressures). High accuracy is confirmed across these conditions. With proper resolution of modeling methods and high-speed numerical solvers, the model executes approximately 30 times faster than real time.
In addition to serving as a fuel cell system simulator, the same modeling and numerical methods are introduced to the control software implemented in a standard engine control unit (ECU) for fuel cell system control. These models run in real-time and act as 'virtual sensors' with which any state variables at any components can be measured and used for on-board calculations. Based on these estimated state variables, simple and high-accuracy feed-forward controllers are developed to improve control response and reduce controller calibration effort.
Finally, the future target of a model-based development process is discussed, in which a combination of 1D and 3D-CFD/FEM based fuel cell system models are utilized as a fundamental piece of the overall development process.

20214294 **Development of 70MPa Hydrogen System Fuel Cell Light-duty Truck**
B1.3 **(Vehicle Modification and Public Road Demonstration 2019, Part 2)**
Kazuya Maita (Tokyo R&D Co., Ltd.)

Abstract:

To lead the world in realizing CO2 reduction in motor traffic utilizing hydrogen energy, we must urgently implement FC vehicles in the field of commercial application following FC automobiles. Commissioned by the Ministry of the Environment*1, Tokyo R&D has developed a fuel cell light-duty truck targeting a fuel efficiency that is 1.75 times more in CO2 emission conversion than that of existing diesel vehicles, validated the vehicle's basic performances and serviceability as a commercial vehicle and is engaged in realizing a basic form of fuel cell light-duty truck.

20214295 **Energy Management System for 70MPa Hydrogen System Fuel Cell Light-duty Truck**
B1.4 *Shigeo Kishi (PUES Corporation)*

Abstract:

To accomplish the CO2 reduction in automobile traffic ahead of other countries utilizing hydrogen energy, we must urgently implement fuel cell vehicles in the field of commercial application following passenger car. Commissioned by the Ministry of the Environment*1, Tokyo R&D and PUES have developed a fuel cell light-duty truck targeting a fuel efficiency that is 1.75 times more in CO2 emission conversion than that of existing diesel vehicles, validated the vehicle's basic performances and serviceability as a commercial vehicle and is engaged in realizing a basic form of fuel cell light-duty truck. As a part of the development, we accomplished control method of fuel cell power according to the remaining amount of the rechargeable battery, which is the key for vehicle energy management, and were able to confirm its useability by actual driving evaluation.

B2 (Special Session): Fuel Cell Stack and Components — Room 2 (14:25-16:05)

Chairs: Akihiro Iiyama (University of Yamanashi)
Kenichiro Ota (Fuel Cell Development Information Center)

20214296 **Development of High-Performance and Low-Cost Second-Generation FC Stack**
B2.1 *Tomokazu Hayashi, Tomoo Yoshizumi, Yuta Ikehata (TOYOTA MOTOR CORPORATION)*

Abstract:

The first-generation Mirai was launched in 2014 as the world's first commercial fuel cell vehicle (FCV).(1) Compared to the FC stack used in the first-generation Mirai, the FC stack in the second-generation Mirai achieved one of the highest volumetric power densities in the world (5.4 kW/L, 1.5 times higher than the first-generation FC stack, excluding end plates) by adopting a new flow channel for the bipolar plate and newly improved electrodes.(2) In addition to improving performance, the cost of FC stack was significantly reduced by the development of materials, structures, and production processes.

20214297 **Multi-Physics Simulation for the Next-Generation Toyota Fuel Cell Stack**
B2.2 **- Application of 3D CAE in Fuel Cell Stack Development –**
Atsushi Yamamoto, Daisuke Hayashi, Kanji Inoko, Katsuya Matsuoka, Michito Norimoto, Atsushi Ida (TOYOTA MOTOR CORPORATION)

Abstract:

The first generation Mirai was launched in 2014 as the world's first commercial fuel cell vehicle (FCV). Since then, model-based development (MBD) has played an important role in the design of vehicles, parts, materials, and production to help reduce cost and size, which are the main issues that need to be resolved to further popularize FCVs in the future. In particular, 3D CAE has become an essential part of the design process for cell performance, properties, and structures of fuel cell assembly components. This paper discusses examples of the application of 3D CAE to the development of the flow field channel, catalyst layer (CL), and gas diffusion layer (GDL) in Toyota's next-generation fuel cell stack.

20214298 **Highly Durable Fuel Cell Cathode Catalyst Layers using Tin Oxide Supports under Load Cycling Conditions**
B2.3 *Chikara Takei[1], Yoshiki Mizushita[1], Kiyoshi Yamaura[1], Katsuyoshi Kakinuma[2], Makoto Uchida[2] ([1]Mitsubishi Motors Corporation, [2]University of Yamanashi)*

Abstract:

Load cycle durability of niobium-doped tin oxide supported platinum (Pt/Nb-SnO_2) was higher than one of graphitized carbon black supported platinum (Pt/GCB) during load cycling as a function of OCV holding time and cathode oxygen concentration. Chemisorbed oxygen species in the presence of the oxygen could affect the growth of the depletion layer on the surface of the Nb-SnO_2 support for highly durable fuel cell cathode catalyst layers during load cycling. We found a novel degradation mechanism of Pt/Nb-SnO_2 during load cycling, which helps to make Pt/Nb-SnO_2 more suitable for automotive applications involving range extender fuel cells.

20214299 **Model Based Development for Zero Emission Vehicles**
B2.4 *Takumi Nunokawa, Takaya Iijima, Naohide Yoshimura (SUBARU CORPORATION)*

Abstract:

In supporting the rapid development of automotive technologies, Model-Based Development (MBD) takes very important role. It helps the process from consideration of basic vehicle architectures to testing of control logics. This paper introduces an application example of MBD on ZEV development. Through this example, MBD's effectiveness for time saving and improvement of certainty in a fresh field of development is shown.

20214300 **Development of High pressure hydrogen storage system for new FCV**
B2.5 **- Mass productivity improvement and production cost reduction -**
Makoto Kojima, Akira Yamashita, Yoichiro Baba, Tomoaki Nishizuru, Shusuke Inagi (TOYOTA MOTOR CORPORATION)

Abstract:

This paper is an introduction of a new pressure hydrogen storage system developed for the purpose of wide spread adoption of fuel cell electric vehicles (hereinafter called FCVs). The high pressure hydrogen storage system consists of high-pressure hydrogen tank, high-pressure valve, high-pressure regulator and piping. It is important for the future wide spread adoption of FCVs to improve mass productivity and reduce production cost while maintaining the performance level of these components. We have improved mass productivity and achieved reduction of production cost by adopting various technology such as new CFRP materials and new processing method for high-pressure hydrogen tank.

B3 (Special Session): Power Electronics Components — Room 2 (16:20-17:20)

Chairs: Kenta Emori (Nissan Motor Co., Ltd.)
Kraisorn Throngnumchai (Kanagawa Institute of Technology)

20214301 **CC/CV Mode with 2DOF Control of Three-Phase AC/DC DAB Converter Based on Matrix Converter**
B3.1 *Moto Takahashi[1], Kenji Natori[1], Jin Xu[2], Noboru Shimosato[2], Yukihiko Sato[1] ([1]Chiba University, [2]Myway Plus Corporation)*

Abstract:

This paper proposes a method for CC and CV modes of a matrix converter-based bidirectional isolated three-phase AC/DC DAB converter. The desired step response and reduction of low-order harmonics are achieved by using 2DOF (two-degree-of-freedom) control. The effectiveness of the proposed method is demonstrated by simulating a laboratory prototype. Using a circuit simulator, the output current when CC mode was applied was compared with that when open loop operation was used. It was confirmed that the 300 Hz component, which is the fundamental frequency of low-order harmonics, was reduced to 20%.

20214302 **A concept of onboard fast battery charging EVs connecting to DC power**
B3.2 *Kazumasa Ide[1], Takuya Ishikawa[1], Kinya Nakatsu[2], Akihiko Kanouda[2], Naomitsu Yoshida[2], Akira Kikuchi[2] ([1]Hitachi Power Solutions Co., Ltd., [2]Hitachi Ltd.)*

Abstract:

The authors propose a system concept of direct power transfer from direct current (DC) power supply system such as photovoltaic (PV) power generation to electric vehicles (EVs). In the system concept, there is an onboard fast battery charging electric vehicles named cEVs those have both traction power supply and onboard fast battery charging functions as a main feature. The cEVs use traction inverters and a newly mounted switching box including a high-frequency transformer for fast battery charging operation. The proposed system, its process of technological thinking and strategy will be presented in this paper. On the basis of this system concept, some useful charging and storage functions as applications of cEVs with DC power system such as PVs are expected.

20214303 **Considerations on DC-bus Current Ripple in Multi-level Dual Active Bridge Converter**
B3.3 *Yasunobu Ueuchi, Ryosuke Ota, Nobukazu Hoshi (Tokyo University of Science)*

Abstract:

In this paper, the DC-bus current ripple characteristics of a three-level neutral point clamped dual active bridge (NPC-DAB) converter applied to V2H (Vehicle to Home) chargers are analyzed and discussed. A three-level NPC-DAB converter's control parameters are represented by a combination of phase shift angle and notching angles. The control parameters that can minimize the DC bus current ripple are investigated. In addition, two types of parameter design methods to reduce the DC-bus current ripple are derived. The output was divided into four regions according to the tendency of the optimal operating parameters. The optimal operating parameters of those regions were discussed, and approximate equations were derived. Also, the effectiveness of the proposed control method was verified in experiments. As a result, it was confirmed that the DC bus current ripple was reduced by 34% at maximum compared to the conventional DAB converter.

C1 (Special Session): Cutting Edge of xEV System — Room 3 (12:30-14:10)

Chairs: Eiji Kuroda (Japan Automobile Research Institute)
Jon Are Suul (Sintef Energy Research / Norwegian University of Science and Technology)

20214304 **Development of the Third-Generation Wireless In-wheel Motor**
C1.1 *Osamu Shimizu[1], Sakahisa Nagai[1], Toshiyuki Fujita[1], Hiroshi Fujimoto[1], Daisuke Gunji[2], Yoichi Omori[3], Takukazu Otsuka[4] ([1]The University of Tokyo, [2]NSK Ltd., [3]TOYO DENKI SEIZO K.K., [4]ROHM Co., Ltd.)*

Abstract:

The authors have developed the third-generation wireless in-wheel motor (W-IWM3) which has the capability of the Dynamic Wireless Power Transfer (DWPT) on its wheel side. The DWPT technology can drastically extend the cruising range of electric vehicles and decrease energy for driving. Developing concepts of W-IWM3 are "all components in wheel", "infinite cruising range", and "industry-academia collaboration open innovation". This paper discusses the concept "all components in wheel" and development of the W-IWM3 with the experimental results.

20214305 **Development of New Electric Vehicle System for small SUV**
C1.2 *Makoto Hirai, Masaya Yamamoto (TOYOTA MOTOR CORPORATION)*

Abstract:

Demand and interest in electrified vehicles such as hybrid vehicles (HVs), plug-in hybrid vehicles (PHVs), electric vehicles (EVs), and fuel cell vehicles (FCVs) is on the increase as environmental awareness rises. In response to this trend of electrification, this paper describes the development of an EV system for small SUVs. The key controls are based on advanced technology developed for HVs and PHVs. As a result, a highly reliable system was developed with an extremely high level of power consumption efficiency and output. High power performance was balanced with a longer cruising range by developing a new high-capacity battery pack and installing it under the floor.

20214306 **Cornering Force Maximization with Variable Slip Ratio Control Based on Brush Tire Model**
C1.3 *Hiroyuki Fuse, Hiroshi Fujimoto (The University of Tokyo)*

Abstract:

With the motivation of the enhancement of the controllability of electric vehicles (EVs), this study proposes an effective slip ratio control method of EVs that maximizes cornering force of each wheel. A variable slip ratio limiter (VSRL) is constructed based on brush tire model in order to increase the lateral force of tire. However, a conventional VSRL did not necessarily maximize cornering force since it did not consider the effect of steering angle and cornering drag force. The new VSRL is proposed here with a basic experimental verification using a real EV. The results confirm the increase of both yaw rate and lateral acceleration while turning at the same speed.

20214307 **Development of an Electric Vehicle with a High-Power Photovoltaic System**

C1.4 *Yosuke Tomita[1], Masanori Saito[1], Yoshiyuki Nagai[1], Yusuke Zushi[1], Tsutomu Tanimoto[1], Kimihiro Nishijima[2] ([1]Nissan Motor Co., Ltd., [2]Sojo University)*

Abstract:

A high-power photovoltaic (PV) system for an electric vehicle was fabricated. The total rated power of the PV panels for this PV system was 1150 W. The base vehicle was a Nissan eNV200, which is an electric vehicle with a battery capacity of 40 kWh.

The PV system generated 3.6 kWh/day on average on the sunny day from May to March. This is equivalent to a range of 24 km for the Nissan eNV200 in the JC08 driving mode. In addition, the PV system could maintain maximum power point tracking (MPPT) control during driving even if the solar radiation changed frequently. And the PV system could also generate power stably under partial shadows compared to the conventional system.

20214308 **An Innovative 2W Hybrid Concept**

C1.5 **A compact non plug-in hybrid platform for augmenting performance and fuel economy of single cylinder engines – 'DVI'**

Kaundinya Ashwin, Garapati Sriyan, Shah Rathin, Ghugal Swapnil, Shah Ravindra, Karle Ujjwala (Automotive Research Association of India)

Abstract:

The push for 2 & 3 W electrification in developing economies is hampered by inadequate infrastructure & grid supply, making these segments ideal for hybridization. DVI consists of a compact crankshaft mounted motor-generator unit, with an intelligent control algorithm that eliminates the need for a decoupling/clutch mechanism between the drives. This allows the system to compliment engine torque, thus allowing the engine to operate in more efficient performance regions. Along with the associated benefits of a HEV, the system significantly improves drivability and is a practical emission-free engine performance upgrade. The system is also designed as a possible retrofit solution.

C2 (Special Session): Connected and Autonomous Technologies on Next Generation xEV — Room 3 (14:25-15:25)

Chairs: Takeshi Kato (Honda R&D Co.Ltd)
Valentin Ivanov (Technische Universität Ilmenau)

20214309 **Advanced Electric Vehicle Components for Long-Distance Daily Trips**

C2.1 *Eric Armengaud[1], Niklas Wikström[1], Joze Buh[2], Miguel Dhaens[3], Sebastian Gramstat[4], Ricardo Groppo[5], Marius Heydrich[6], Valentin Ivanov[6], Matteo Mazzoni[7], Aldo Sorniotti[8] ([1]AVL List GmbH, [2]Elaphe Propulsion Technologies Ltd., [3]DRiV, [4]AUDI AG, [5]Ideas & Motion Srl, [6]Technische Universität Ilmenau, [7]Brembo S.p.A., [8]University of Surrey)*

Abstract:

This paper introduces a holistic engineering approach for the design of an electric sport utility vehicle focused on the reliable capability of long-distance daily trips. This approach is targeting integration of advanced powertrain and chassis components to achieve energy-efficient driving dynamics through manifold contribution of their improved functions. The powertrain layout of the electric vehicle under discussion is designed for an e-traction axle system including in-wheel motors and the dual inverter. The main elements of the chassis layout are the electro-magnetic suspension and the hybrid brake-by-wire system with electro-hydraulic actuators on the front axle and the electro-mechanical actuators on the rear axle. All the listed powertrain and chassis components are united under an integrated vehicle dynamics and energy management control strategy that is also outlined in the paper. The study is illustrated with the experimental results confirming the achieved high performance on the electric vehicle systems level.

20214310 **A dynamic game-based distributed approach for efficient cooperative traveling at an isolated intersection**

C2.2 *Kaizheng Wang, Yafei Wang, Lin Wang, Jingkai Wu (Shanghai Jiao Tong University)*

Abstract:

Interactivity is necessary to resolve conflicts at an isolated intersection. In consideration of enhancing the interactive characteristics of vehicles at an unsignalized intersection, a two-layered method, including the game-based layer and optimization-based layer, is proposed for safe and efficient traveling. In the game-based layer, a bargaining game is designed for more efficient strategies. In the optimization-based layer, the model predictive control (MPC) is applied for optimization with the consideration of the executability the vehicle. The simulations with comparison between the proposed two-layered method, cooperative game-based method, and noncooperative method are carried out. The results demonstrate that the traffic efficient at an unsignalized intersection is improved while the safety is guaranteed by the proposed method.

20214311 **Research Achievements and Future Perspectives of Electric Vehicle and Power Grid Integration**
C2.3 *Yutaka Ota (Osaka University)*

Abstract:

Electric vehicle (EV) and power grid integration is important issue for forecasting zero-emission society, for designing functionality of electric vehicles, and for expanding efficient charging infrastructure, and so on. Smart charging from renewable energy resources is to be achieved by collaboration effort with utility companies, resource aggregators of vehicle fleet and/or energy management, and automotive manufactures. Recently, V2X(Vehicle-to-X) oriented energy resilience have been expected at public facilities, disaster shelter places, office buildings, and residences. In this paper, possibility and necessity of electric vehicle and power grid integration is suggested from the fundamental analyses of vehicle usage data and the V2X demonstration achievements. Integrated system stricture over power and automotive sectors are to be described. The author mentions about availability and possibility of integrated electric vehicle information such as GPS location, vehicle speed, onboard battery power output, battery SOC(State-of-Charge), accessory power, and so on, through his experiences on the smart charging and V2X experiments.

C3 (Special Session): Advanced xEV Motion Control & Dynamics — Room 3 (16:20-18:00)

Chairs: Hiroshi Fujimoto (The University of Tokyo)
Husam Muslim (Japan Automobile Research Institution / University of Tsukuba)

20214312 **Hill Ascent Descent Control for AWD Electric Vehicles**
C3.1 *Shoto Arai (SUBARU CORPORATION)*

Abstract:

Electric vehicles (EVs) have characteristics of high torque at low rpm and quick and accurate torque control. We aimed to develop AWD EVs that take advantage of these characteristics and established Hill ascent descent control (HADeC) for front-rear independent motor EVs. The Concept of HADeC is that drivers can drive at the set vehicle speed (2~10km/h) and concentrate on operating the steering wheel without accelerator operation during HADeC driving. The function consists of the feedback control of speed and slip ratio control. Drivers can drive on rough roads (ex. Climbing gravel roads with slip and step roads) with confidence by using HADeC.

20214313 **How Drivers Gender, Age, and Experience Affect Human-Automated Vehicle Interaction during Traffic Congestion on Highways**
C3.2 *Husam Muslim[1,2], Jacobo Antona-Makoshi[1], Nobuyuki Uchida[1], Cho Kiu Liang[2], Makoto Itoh[2] ([1]Japan Automobile Research Institution, [2]University of Tsukuba)*

Abstract:

This study conducted a driving simulation experiment to compare four automated driving systems (ADS) during lane change demanding situations on highways, while accounting for the drivers' gender, age, and experience. While an ADS is activated, the vehicle approaches a traffic congestion on the left-hand lane. ADS-1 can reduce the speed to synchronize with the congestion. ADS-2 reduces the speed and issues an optional request to intervene advising the driver to change lanes manually. ADS-3 offers to overtake the congestion autonomously if the driver approves it. ADS-4 overtakes the congestion autonomously without driver's approval. Results of drivers reaction and acceptance indicated that differences between ADS designs increase when consider the combined effect of drivers gender, age, and experience more than when the effect of each factor is considered separately. These findings, while preliminary, may help us to understand how ADS users' behavior can differ based on several demographic human factors.

20214314 **System Cost Optimization of e-Drives – Method and Application**
C3.3 *Timo Wehlen[1], Stephan Scharr[1], Hiroyuki Sakaguchi[2] ([1]ZF Friedrichshafen AG, [2]ZF Japan Co., Ltd.)*

Abstract:

As EV market opportunities are growing with market size, e-drive system optimizations are key to improve its technical competitiveness and cost structure for market success. Within an e-drive pre-development project, a multidisciplinary formed team worked on a methodology called 'system cost optimization' and its application.

20214315 **Development of New Plug-in Hybrid System for SUV**
C3.4 *Makoto Tomita, Koichi Ichikawa, Takenori Kobayashi, Yusuke Seo, Kazuma Aoki, Yuji Omiya, Yasuo Suzuki (TOYOTA MOTOR CORPORATION)*

Abstract:

A new plug-in hybrid vehicle (PHV) system has been developed for the RAV4 PHV. This development aimed to comply with the environmental regulations of various regions and to achieve high power performance that surpasses the Prius PHV. To realize these objectives, a new lithium (Li) traction battery (18.1 kWh) and double boost converter system were developed. Furthermore, to mount the PHV system in the SUV without compromising comfort, space, and utility, the new traction battery was installed beneath the vehicle floor. The battery cells are cooled using refrigerant from the vehicle's air conditioning system, thereby reducing the size of the system and helping to maintain performance in EV mode. The result is a PHV system with high power and environmental performance.

20214316 **Seamless Shifting in 2-Speed eAxle Integrated with Torque Sensor and Multifunctional Shifting Device**
C3.5 *Shota Yamada, Shohei Kaneko, Hirotaka Kishida, Akihiro Yamamoto (NSK Ltd.)*

Abstract:

Introduction of 2-speed transmissions into EVs can improve cruising range and driving performance. There are two requirements for 2-speed transmissions in EVs; 1) large step ratio to maximize cruising range and 2) compactness to be comparable to fixed-ratio eAxle in mountability. Shifting in large-step-ratio transmission causes severe shock deteriorating driving comfort. This paper proposes a 2-speed transmission with a magnetostrictive torque sensor for robust seamless shifting. Feedback control with the output torque sensor makes seamless shifting possible without tuning of controller parameters. Moreover, we propose a multifunctional shifting device using a single electric actuator to downsize 2-speed eAxle. The advantages of the developed 2-speed transmission are verified through seamless shifting experiments.

May 25 (Tue.)

D1 (Special Session): Wireless Power Transfer I **Room 1 (12:30-14:10)**

Chairs: Takeshi Hikage (Hokkaido University)
Yukio Yokoi (Takushoku University)

20214317 **Geometric View to Class-E Operation of RF Power Inverters**
D1.1 *Takashi Ohira (Toyohashi University of Technology)*

Abstract:

This paper revisits the theory of class-E inverters using plane geometry. Given the circuit's constituent LCR parameters and DC supply voltage, the harmonic balance technique derives three linear equations for DC current consumption and RF output wave. These linear equations can be algebraically solved, but their general solutions result in complicated functions of the LCR parameters. When the LCR parameters are adjusted to meet the zero-voltage-switching (ZVS) condition, the solutions become quite simplified. We find that the ZVS condition draws a semicircle on a complex load impedance plane, where an off-nadir angle signifies the inverter's output phase. We also find another semicircle designating the zero-voltage-derivative-switching (ZVDS) condition on the same plane. The two semicircles intersect at a single point signifying the class-E inverter's nominal load impedance. A load-pull consideration clarifies the output voltagecurrent relation, and yields a straight line locus on the *V*-*I* plane. From this line's intercepts and slope, we find the inverter's Thévenin equivalent whose output impedance is $4/\pi^2$ times the nominal load resistance. Along with these outcomes, we also show useful mathematical expressions of the RF output power and DC-RF conversion efficiency in terms of the load resistance.

20214318 **Power Transmission Characteristics of LCC Compensation Network to Coupling and Load Variation**
D1.2 *Kodai Takeda[1], Toshiyuki Fujita[1], Takehiro Imura[2], Takafumi Koseki[1] ([1]The University of Tokyo, [2]Tokyo University of Science)*

Abstract:

A compensation circuit design is an important issue in wireless power transfer technology. This paper proposes a visual analysis of power transmission characteristics, especially focusing on power factor of the source, of LCC/LCC compensation circuit. The visual analysis reveals LCC/LCC compensation circuit has different resonance constraints from the conventional ones to maintain unit power factor. A numerical verification is conducted and shows good agreement with the theoretical estimation.

20214319 **Flying-capacitor Linear Amplifier with N-channel MOSFETs for Radiation Noise Reduction of Wireless Power Transfer System**
D1.3 *Rintaro Kusui, Keisuke Kusaka, Jun-ichi Itoh (Nagaoka University of Technology)*

Abstract:

This paper proposed a flying-capacitor linear amplifier (FCLA) for wireless power transfer (WPT) systems. The proposed FCLA consists of only n-channel MOSFETs and an unfolder in the output stage. The FCLA with the unfolder output a sinusoidal voltage and current. Due to the sinusoidal output, the radiation noise harmonics from transmission coils reduces. First, the proposed FCLA configuration and control method is explained. Then, the operation of the proposed FCLA connected to the WPT system is demonstrated by simulation. In addition, harmonic components of current on a primary coil are analyzed. As a result, it is confirmed that the third-order harmonic component is reduced by 49.1 dB in comparison with a conventional two-level inverter. Finally, it is confirmed that the flying capacitor voltage is automatically balanced by a prototype with two-series MOSFETs in the upper arm. Furthermore, the third-order harmonic output voltage is reduced by 19.8 dB compared to the square wave.

20214320 **Basic Study of Integrated On-board Converter for Dynamic WPT EV**
D1.4 *Ryosuke Ota, Nobukazu Hoshi (Tokyo University of Science)*

Abstract:

In dynamic wireless power transfer (DWPT) EVs, though a DWPT system and a motor-drive (MD) system are onboarded, these systems have individually been examined so far. For this, if these systems are connected, the number of the conversion stage is also simply increased. That causes an increase in power loss. As a solution to this problem, this paper proposes a multiport active-bridge converter to integrate both systems. In a simulation, the proposed system and the conventional system were compared, and then it was confirmed that the proposed system was more efficient by 2.0 pt than the conventional system.

20214321 **Efficiency Maximization of Wireless Power Transfer Systems with Resonance Frequency Mismatch**
D1.5 *Katsuhiro Hata (The University of Tokyo)*

Abstract:

Magnetic resonance wireless power transfer (WPT) is designed so that the resonance frequencies of the transmitter and receiver match well, but in practice, the resonance frequency mismatch occurs due to the parameter variations of the system components. In this paper, the efficiency characteristics of the WPT system with the resonance frequency mismatch are analyzed and a method for maximizing the efficiency is proposed according to the operating frequency setting. Furthermore, the efficiency characteristics are generally described using new parameter, resonance frequency mismatch coefficient, in addition to *kQ* product. The simulations and theoretical analysis verify that the maximum efficiency can be tracked by using the proposed optimum load resistance.

D2 (Special Session): Wireless Power Transfer II — Room 1 (14:25-16:05)

Chairs: Katsuhiro Hata (The University of Tokyo)
Takasnhi Ohira (Toyohashi University of Technology)

20214322 **A Study on Optimization of Wireless Power Transmission Ferrite-less Coils in the 85 kHz Band by Numerical Analysis**
D2.1 *Yuto Yamada, Takehiro Imura (Tokyo University of Science)*

Abstract:

Wireless Power Transfer (WPT) has received a great deal of attention in recent years. Wireless power transfer for Electric Vehicles (EV) is becoming more important as a key factor in the popularization of EVs. Although the efficiency of wireless power transfer by magnetic field resonance can be evaluated by the *kQ* product, the optimum coil design method that maximizes the *kQ* product at a specific frequency has not yet been established. In the previous research, it is very troublesome because the electromagnetic field analysis was repeated by trial and error. In this paper, the *kQ* product is modeled for the number of turns in the Test Stations GA-WPT1 and VA-WPT1/Z3, which are defined in the international standard SAE J2954, and the coil that achieves the maximum efficiency is evaluated in terms of the number of turns. Although some errors in the modeling of the *kQ* product are expected to occur, a high-efficiency coil design plan is presented with almost no errors in terms of efficiency.

20214323 **Development of thin sheet coil for EV-WPT**
D2.2 **- Proposal of a new type coil unit -**
Masato Okabe, Junya Otsuki, Hiroyuki Hase, Hiroomi Katagiri (Dai Nippon Printing Co., ltd.)

Abstract:

The authors are studying a coil composed of thin metal instead of hand winding a Litz wire. We have reported that the magnetic field leakage radiated from the thin sheet coil is reduced. 1) We have repeatedly studied the line pattern and layer structure of the seat coil and succeeded in further reducing the thickness and weight and improving the transmission performance. The improved coil significantly reduced the amount of copper material used in it and is also effective in reducing material cost and manufacturing process costs. In this paper, we report the features of the new seat coil.

20214324 **Coil Performance and Evaluation of Pavement Durability of Dynamic Wireless Power Transfer System using Ferrite-**
D2.3 **less and Capacitor-less Coil for Road Construction Methods**
Takehiro Imura[1], Koki Hanawa[1], Kanta Sasaki[1], Nagato Abe[2] ([1]Tokyo University of Science, [2]Toa Road Corporation)

Abstract:

The development of technology for embedding coils in roads is important for dynamic wireless power transfer (DWPT). When embedding coils in a road, it is necessary to ensure both the electrical and mechanical properties required for DWPT. In this study, coils are produced using PP and PE, which are synthetic resins. In addition, the coil is mainly an open-type coil without the ferrite and capacitor. The electrical characteristics of the coil were evaluated before and after burying it. Further, we evaluated the mechanical strength of the road before and after the coils were buried using the falling weight deflectometer test. Four construction methods were investigated. The deformation of the inside of the coil was measured using strain gauges, and during paving, the effect of the heat of the asphalt in the space inside the coil was measured using thermocouples. A comprehensive evaluation of the electrical and mechanical properties of the synthetic resin coils was conducted when they were paved. The results show that the reflection crack suppression sheet (RC mesh) method is currently the best construction method. Moreover, it was found that injecting cement grout to protect the coil was the best way to reduce the residual strain.

20214325 **Geometric Coverage Evaluation for Variable Impedance Tuners in View of Poincaré Distance on the Smith Chart**
D2.4 *Asako Suzuki[1], Takayuki Matsumuro[2], Toshio Ishizaki[2], Takashi Ohira[3] ([1]Fujiwaves CO.,LTD., [2]Ryukoku University, [3]Toyohashi University of Technology)*

Abstract:

This paper explores the Poincaré distance from a continuously varying load impedance on the entire Smith chart to obtain a clearer vista on the matching circuit's impedance behavior. We draw the impedance and constant-distant contour, and color the area within the contour. From the area, we estimate the coverage area percentage (CAP) that meets a specified distance from a given point on the Smith chart. We have done them with several types of circuits: lumped-constant (LC) matching circuits, spiral trajectory matching circuit, and clover locus matching circuit. Visualization of matching area and CAP identify which circuit we shall take in the system design.

20214326 D2.5 **Conditions for maximum energy transfer in inductive road-powered electric vehicle applications taking system limitations into account**

Giuseppe Guidi[1], Jon Are Suul[1,2], Hiroshi Fujimoto[3] ([1]Sintef Energy Research, [2]Norwegian University of Science and Technology, [3]The University of Tokyo)

Abstract:

This paper deals with the problem of maximizing the energy transfer between infrastructure for inductive power transfer embedded in the road and a moving electric vehicle. The analysis is assuming a series-series compensated inductive power transfer architecture and the problem is solved analytically to obtain general solutions expressed in terms of basic coil parameters and coupling. Based on the analytical solutions, control algorithms aiming at maximum energy transfer during the vehicle motion are developed, resulting in optimal utilization of the infrastructure. Numerical simulations and experimental measurements are used to validate the proposed method. It is shown that by using power transfer maximization control, the amount of energy transferred from the road infrastructure to a moving vehicle can be significantly increased compared to using conventional techniques. In this paper, about 10% higher energy could be transferred without changing the current and voltage ratings of the coils and converters. Higher gain is expected for different system designs with road and on-board coils more similar in size.

E1 (Special Session): Energy Storage Devices & Systems I
Next-Generation Batteries and Capacitors — Room 2 (12:30-13:50)

Chairs: Chihiro Yada (TOYOTA MOTOR CORPORATION)
Hiroyuki Akashi (Envision AESC Japan Ltd.)

20214327 E1.1 **Advanced Analytical Techniques for All-solid-state Batteries**

Keigo Atobe, Yoshitake Honda, Masazumi Arao, Norio Saito, Toru Akiba (NISSAN ARC, Ltd)

Abstract:

Improving the ion conductivity across various kinds of interfaces inside all solid state battery (ASSB)-related materials, is one of the key issues in optimizing the performance of ASSB. To support the research and development of ASSB, we have been developing various characterization methods to evaluate electrolyte structures and ionic conductivities.

In this paper, we present our analysis technologies applied to optimize electrolyte structure and interface control in ASSB. Firstly, as approach of structure optimization, simulation of solid electrolyte in compressed state is introduced. By using simulation together with analysis which is difficult to realize experimentally, it provides us unique ways to reproduce the state in the battery. Secondly, as techniques of interface control, it is known that the cell performance could be greatly improved by coating the positive electrode surface with LiNbO3 (LNO). The condition of the coating distribution was investigated and the performance improvement was understood by electrochemical measurements of the cell.

20214328 E1.2 **Investigation on the thermal behavior of all-solid-state batteries with sulfide electrolytes**

Mitsumoto Kawai[1], Koichi Sugiura[1], Takuya Miwa[1], Yoshiyasu Saito[2] ([1]LIBTEC, [2]AIST)

Abstract:

The thermal stability of all solid state lithium-ion batteries with Argyrodite-type sulfide solid electrolyte (ASSBs) and conventional lithium-ion batteries with liquid electrolyte (LIB) both under 4.2V charging state vs anode potential were investigated using the accelerating rate calorimetry (ARC) to compare thermal runaway behaviors. The Calvet-type heat flux calorimetry (C600) were used to measure heat flow and evolved gas pressure from the batteries. The results showed that thermal runaway reaction with chain reaction may not be happened in ASSBs whereas it happened in LIBs. In other words, each reaction of thermal runaway could be isolated and a previous reaction could not trigger next reactions in our ASSBs even in adiabatic condition. These results suggest that ASSBs be safer than LIBs in terms of thermal stability.

20214329 E1.3 **Li-ion Battery in All Solid State toward High Energy and Power Densities: Focus on Lithium Superionic Conductor as Key Material**

Satoshi Hori, Ryoji Kanno (Tokyo Institute of Technology)

Abstract:

All-solid-state Li-ion batteries, in which an organic liquid electrolyte is replaced by a solid electrolyte inside the conventional Li-ion battery, has been extensively studied worldwide because the solid-state configuration potentially improves the energy and power characteristics as well as expands the operation temperature range. This article discusses the expected advantages of all-solidstate batteries, some of which have been supported by recent studies. The development of $Li_{10}GeP_2S_{12}$-type solid electrolytes, which are key materials to enable high-performance all-solid-state Li batteries, through our new research framework (OPERA) is briefly described.

20214330 **Development of high-power energy storage devices for future automotive applications**
E1.4 *Shuichi Ishimoto, Yoshihiro Minato, Kenji Tamamitsu (Nippon Chemi-Con Corporation)*

Abstract:

We have developed high-power energy storage devices using nano-sized (battery) redox electrode materials, which we call Super Redox Capacitors (SRCs), for future automotive applications. As the nano-sized redox electrode materials, the nano-sized lithium titanate (LTO) and nano-sized lithium vanadium phosphate (LVP)/multiwalled carbon nanotube (MWCNT) composite were successfully prepared through collaborative work with Tokyo University of Agriculture and Technology. Two different SRC cells were assembled and their electrochemical performances were characterized; i) nano-LTO//conventional lithium manganate (LMO) and ii) nano-sized LTO//nano-sized LVP composite. Both SRC cells showed high power performances of 5-7 kW/L with over10 times higher energy density than the conventional EDLC. In addition, SRC cells also exhibited an excellent low temperature performance down to -40 ℃, showing that the SRCs possess promising performance as a high-power energy storage device for automotive applications.

E2 (Special Session): Energy Storage Devices & Systems II Systems and Applications — Room 2 (14:25-15:45)

Chairs: Kenji Natori (Chiba University)
Noriko Yoshizawa (National Institute of Advanced Industrial Science and Technology (AIST))

20214331 **Residual performance evaluation of Lithium-ion batteries for their secondary use**
E2.1 **- Fast and reliable methodology based on electrochemical impedance spectroscopy –**
Takumi Mori, Nozomu Teranishi (HIOKI E.E. CORPORATION)

Abstract:

With the explosive widespread of lithium ion batteries (LIBs), the performance estimation of them with limited hardware and/or computational resources becomes more and more important. In this study, a statistical machine learning method based on the electrochemical impedance spectroscopy (EIS) data is applied to conveniently estimate the state of health (SOH) of LIBs. Establishment of a stable, safe and fully-automated measurement system to accumulate the characteristics data of LIBs at their various states is necessary for realization of a new SOH estimation method for the LIBs whose usage histories are not recorded or not available. The LIB test system developed and the SOH estimation ability of the algorithm are described.

20214332 **Development of Battery Characteristic State-evaluation Method Using High-speed Pulse Measurement**
E2.2 *Noboru Oyama, Shuichiro Yamaguchi, Lin Furudate, Yasuhiko Ohsawa, Yasumasa Mochizuki (EnNet Co., Ltd., Lab. 307 at Tokyo metropolitan industrial technology research institute)*

Abstract:

It is demonstrated that battery-states such as the health-level and measurement-temperature can be quickly evaluated by machine learning means. The capacity ratio of a full charge to an initial full charge, which was measured from charge-discharge curves, can be estimated with high accuracy at high speed by the method described here and therefore used as a reuse indicator and life diagnosis for batteries in use. The ability of the prototype diagnostic device is also introduced.

20214333 **New Lithium-ion Battery System for Nissan KICKS e-POWER**
E2.3 *Kenji Ohara, Takamasa Nakagawa, Yoshio Shimoida (Nissan Motor Co., Ltd.)*

Abstract:

In order to realize smooth and powerful drive feeling by 100% motor drive with top level fuel economy, battery system should have especially high power performance and compact pack layout. Cell power performance improvement, the battery pack design including cooling system challenges and the control improvement for battery system are key contributors. In this paper we describe about technical improvement points for battery system of Nissan KICKS e-POWER.

20214334 **Overview of Applications of Energy Storage System to Rail Vehicle Traction**
E2.4 *Hiroyasu Kobayashi, Keiichiro Kondo (Waseda University)*

Abstract:

Energy storage systems are key technology of future transportation system. In terms of electric vehicle or plug-in hybrid vehicle, energy storage system has an impact on a traction characteristics and cruising distance. In the case of rail vehicle, onboard energy storage system is also developed recently. In this paper, variations of rail vehicle powertrain with energy storage system is investigated. Furthermore, technical trends are also presented.

E3 (Special Session): Energy Storage Devices & Systems III
Lithium-ion Battery Technologies **Room 2 (16:20-17:20)**

Chairs: Daichi Imamura (Japan Automobile Research Institute)
Kazuhiro Sakuma (Materials Innovation Tsukuba, Inc.)

20214335 **Technology Trend and Future Prospect of Large Li-ion Battery**
E3.1 *Hiroyuki Akashi (Envision AESC Japan Ltd.)*

Abstract:

The technological evolution of automotive lithium-ion batteries is widely recognized as a key driver for the widespread use of electric vehicles, and more in recent years, they have also begun to attract attention for their ability to function as an electric energy buffer to temporarily store energy from renewable energy generation devices such as wind and solar power. With the spread of electric vehicles in the future, the recycling of used batteries is also an urgent issue that needs to be addressed as part of the resource and environmental issues. In this presentation, we will focus on the technology roadmap of lithium-ion batteries for automotive use and our efforts for the recycling of environmental issues in the future electric vehicles and sustainable society.

20214336 **Diagnosis of traction batteries in driving mode**
E3.2 **- Increasing the accuracy of battery state of charge estimation by using a multiple battery concept -**
Jonas Maier[1], Dan Keilhoff[2], Hans-Christian Reuss[2] ([1]Research Institute of Automotive Engineering and Vehicle Engines Stuttgart (FKFS), [2]Institute of Automotive Engineering (IFS))

Abstract:

The dominant technology these days are lithium-ion battery cells. To ensure a long service life, monitoring and diagnosis of the energy storage systems state is essential. This paper presents the currently used algorithms for State-of-Charge estimation and gives an outlook on how to increase the accuracy of the methods by a different hardware concept. The aim of this concept is to improve the safety and lifetime of the traction battery by more accurately predicting its condition.

20214337 **Development of Carbon Nanospheres as Negative Electrode in Lithium Ion Batteries with High Power Performance**
E3.3 *Noriko Yoshizawa (National Institute of Advanced Industrial Science and Technology (AIST))*

Abstract:

Structure of graphitized carbon nanosphere (CNS) particles, known as their superior high-rate charge-discharge performances in Li-ion batteries, was investigated. According to the TEM observation, high concentration of defects along the ridgeline of the polyhedronized particles was confirmed. Such gathering of the structural defects can be considered to play an important role for the efficient charge-discharge process in the graphitized CNS particles. Electrochemical behaviors of CNSs in EC+DEC or PC-based electrolyte were also investigated to see interaction with electrolyte on the surface of the particles.

F1: Safety and Security for E-mobility and Infrastructure **Room 3 (12:30-13:30)**

Chairs: Yasuo Matsunaga (Nissan Motor Co., Ltd.)
Takahiro Noyori (AVL JAPAN)

20214338 **Simulation Analysis of Automatic Braking System Performance Based on Improved TTC Model**
F1.1 *Yanhui Xing, Yuhai Wang, Jianlong Hu (Jilin University)*

Abstract:

Autonomous Emergency Braking (AEB) is the most common type of automobile active safety technology, which can effectively reduce the occurrence of rear-end collision accidents. This paper built a vehicle Simulink model with the WEY VV6 as the prototype, and carried out simulation verification on the braking performance of the model. Based on the traditional TTC (Time to Collision) model, this paper proposed an improved TTC model. Combined with the needs of vehicle operating conditions, the automatic brake system strategy design was completed. This paper also established a hierarchical control strategy based on vehicle speed. Taking safety and comfort as the evaluation indicators, according to the relevant regulations of the 2018 version of C-NCAP, based on the vehicle Simulink model, this paper carried out simulation verification on the control strategy of the braking system. According to the result of the comparative analysis, the control strategy based on the traditional TTC model and the improved TTC model can both avoid collisions, and their safe parking distance is more than 1m, but the improved TTC model has better comfort.

20214339 **Virtual Test Drive Framework**
F1.2 **Real World to Virtual Road Network**
Martin Kehrer[1], Gerd Baumann[2], Hans-Christian Reuss[2] ([1]Research Institute of Automotive Engineering and Vehicle Engines Stuttgart (FKFS), [2]Institute of Automotive Engineering (IFS))

Abstract:

In this paper a method for the creation of virtual road networks based on real road measurement data is presented. Thereby an approach is chosen, which considers the German road construction guidelines as well as the requirements regarding the execution of a Driver-in-the-Loop simulation (DiL). For the fastest and easiest possible creation of such road networks, the method does not use cost-intensive road survey data, rather the freely available OpenStreetMap data sets is used as baseline

20214340 **Functional Safety and Hazard Analysis as per ISO26262 for a Retrofit P3 Hybrid LCV Controller**
F1.3
Ghugal Swapnil[1], Shah Rathin[1], Shah Ravindra[1], Lemos Nisha[1], Karle Manish[1], Karle Ujjwala[1], Leischke Fabian[2], Grosse Siestrup Leopold[2] ([1]The Automotive Research Association of India, [2]IAV GmbH)

Abstract:

The world is shifting towards a low carbon footprint which has made it necessary to adopt efficient technologies with lower emissions. Hybridization is one such solution, which results in improved efficiency and reduced emissions that can meet the future emission norms. Along with standard hybrid vehicles with automatic transmission, there is a push on retrofitting of hybrid powertrain into conventional IC vehicles with manual transmission. In development of such retro-fitment solutions, safety is one of the key issues with the increasing technological complexity, software content and mechatronic implementation as there are increasing risks from systematic failures and hardware failures. The ISO26262 series of standards has been developed specifically to address functional safety of E/E systems of on-road vehicles that is achieved through a safety concept that is developed according to a systematic process as defined in ISO26262.

ARAI has developed an intelligent vehicle controller (iVCON) for a unique retrofit solution kit of P3 hybrid vehicle architecture. The vehicle identified for proof of concept was a commercial vehicle equipped with manual transmission conventional powertrain. The idea was to build the retro-fitment kit, which will be converting the existing vehicle in P3 hybrid with additional electric powertrain. The challenge was to develop a controller (Intelligent Vehicle Controller- iVCON) which would operate the conventional powertrain including a manual transmission, as well as the electric powertrain ad on. Looking at the complexity of operating conditions and manual interventions in terms of gear selections, the safety aspect of the vehicle is very important to consider. Hence, the controller design analysis was done as per the guidelines under ISO26262 to be functionally safe. Development and integration of complex automotive control functionalities requires implementation of functional safety as a parallel process. During implementation, the supporting evidences and artifacts have to be created and documented. This paper attempts to show the increase need for functional safety for this retrofit P3 application by systematic analysis of item under consideration according ISO26262.

F2 (Special Session): Design, Evaluation and Related Technologies for Vehicles — Room 3 (14:25-15:45)

Chairs: Yoshitaka Asakura (AYE)
Daisuke Gunji (NSK Ltd.)

20214341 **Distributed Local X-in-the-Loop Environment**
F2.1 **- A Tool for Electric Vehicle Systems Design -**
Christoph Lehne[1], Valentin Ivanov[1], Klaus Augsburg[1], Florian Büchner[1], Viktor Schreiber[1], Jernej Herman[2], Jure Pašič[2], Blaž Zavrl[2] ([1]Technische Universität Ilmenau, [2]Elaphe Propulsion Technologies Ltd.)

Abstract:

The paper describes methodology and corresponding environment for development, validation and testing of complex electric vehicle (EV) systems. The proposed approach is based on distribution of relevant design tasks between remotely working testing equipment with real-time (RT) data sharing and data exchange. The approach is demonstrated by the example of X-in-the-loop (XIL) environment uniting electric motor test setup, hardware-in-the-loop (HIL) platform with brake-by-wire system, and the brake dynamometer. The study introduces how this configuration of experimental tools can be used by designing the brake blending and control of an EV.

20214342 **Real Time Simulation of Motor Drive System Modeled in FPGA based Hardware-In-Loop Simulator**
F2.2 **- Dedicated architecture for 200ns simulation time step and 3.5ns PWM resolution -**
Noriyasu Matsuno, Jun Sugiyama (Myway Plus Corporation)

Abstract:

The demand for real time simulation in motor drive system has been more significant since more advanced control algorithm and implementation should be verified more thoroughly and safely. HIL(Hardware-In-Loop) technology has been introduced to respond this need, however in motor drive application a carrier frequency would be on the order of 20kHz or higher and this may require 5us or less sampling time. Introduced FPGA base PE real time simulation platform enables 200ns time step, 3.5ns over sampling for universal PE application including motor drive with various motor model including non-linear model.

20214343 F2.3 **Powertrain Selection of Electrical Compressor vs Electrical Motor Using Hybrid Electrical Vehicle Modeling Tool (HEVMT)**

Bo Yang (Booterr Consulting)

Abstract:

Vehicle powertrain with electrical hybridization is a wide accepted approach to improve vehicle fuel economy and reduce emission. Electrical generator and battery can recuperate and save the vehicle energy when vehicle is in deceleration stage. The recovered energy in hybrid vehicle can be used as torque assist to vehicle through electrical motor, which reduce the internal combustion engine working duration and put internal combustion engine working in high efficiency area. Another approach to use the recovered energy is to motorize other component, like electrical compressor, which can improve the base engine thermal efficiency. This paper shows the comparison of three utilization methods of energy saved in the battery in hybrid electrical vehicle. First is the direct application of the saved energy on vehicle through electrical motor (e-Motor), the second is to apply the saved energy on the electrical compressor (e-Compressor) to boost the performance of internal combustion engine and reduce the fuel consumption. The final approach is to utilize both the e-Motor and e-Compressor to improve the vehicle fuel economy. By using an in-house developed hybrid electrical vehicle modeling tool (HEVMT), the pro and con of each powertrain combination was analyzed and presented with the assumption of certain control strategy. It was showed that powertrain with e-Compressor has better fuel economy than the powertrain with only e-Motor in urban and highway driving schedule. The powertrain with both e-Compressor and e-Motor has the best fuel economy among the three powertrain combinations, but with reduced benefit.

20214344 F2.4 **Intelligent Vehicle Controller (iVCON) Platform for xEV**

Ghugal Swapnil, Shah Rathin, Shah Ravindra, Pachhapurkar Ninad, Karle Ujjwala (The Automotive Research Association of India)

Abstract:

Indian consumers are increasingly looking to buy a hybrid vehicle over conventional powertrain-driven ones on the back of supportive environmental policies, big-brand bets and shift in buyers' mindset. The Governmnet of India is also pushing for same, as part of the NEMMP 2020, Department of Heavy Industry formulated a Scheme viz. Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles in India (FAME India) Scheme to promote manufacturing of electric and hybrid vehicle technology and to ensure sustainable growth of the same. To cater to this dynamic change happening in automotive industry, we developed the indigenous software package for the vehicle controller of xEVs. The package is an Intelligent Vehicle Controller (iVCON) which is the suite of the standard control algorithm used to control the xEV applications. Especially in case of xEVs, the master vehicle controller is very important since it has to control the demands going to separate systems (like Electric motor, Engine, Battery, etc.). The efficient controller which controls the power flow as per the requirement of the vehicle demand and resources available is key for the hybrid operation.

The unique aspect of this controller is the unversatility where it can be used to develop soft controller for any type of xEV configuration. The generated controllers are MIL, SIL and RCP deployable thereby giving the developers/engineers a headstart in xEV control development without any need or knowhow of matlab programming and control systems development. This software package is user friendly configurable solution which will give the control module in MATLAB environment. User has to select the application HEV/EV and input basic parameters of the vehicle. The utility will create controller in soft format as per the application selected and parameters provided and the controller has offline and Real-Time Simulation Capablities.

F3 (Special Session): Energy Transmission Systems to Vehicles and Global Warming I — Room 3 (16:20-17:40)

Chairs: Osamu Shimizu (The University of Tokyo)
Kenji Morita (Japan Automobile Research Institute)

20214345 F3.1 **Development of Middle Speed Dynamic Wireless Power Transfer Simulation Test Bench**

Daisuke Gunji[1], Sakiya Watanabe[1], Yukitaka Matsuoka[2], Sakahisa Nagai[3], Osamu Shimizu[3], Hiroshi Fujimoto[3] ([1]NSK Ltd., [2]Japan Automobile Research Institute, [3]The University of Tokyo)

Abstract:

Dynamic charging technology (also called Electric Road System) is one of a possible solution to improve usability of Electric Vehicles (EVs). The authors have developed Dynamic Wireless Power Transfer (D-WPT) system using magnetic resonance coupling technology. Technical challenges of D-WPT are follows: (a) Transmit power control method of both transmitter side and receiver side, (b) Vehicle detection method to start and stop power transfer, (c) EMC and safety for human, (d) Foreign object detection. For these research and developments, a test bench that can simulate driving situation is required to carry out reproducible experiments. The authors have developed a D-WPT simulation test bench that can simulate 30 km/h driving. This paper describes the details of the device and the experimental results.

20214346 **V2B Vehicle to Building Charging Manager**
F3.2 **- Concept and Implementation -**

Martin Stadie[1], Tobias Rodemann[2], Andre Burger[1], Florian Jomrich[1], Steffen Limmer[2], Sven Rebhan[2], Hibiki Saeki[3] ([1]Honda R&D Europe (Germany) GmbH, [2]Honda Research Institute Europe, [3]Honda R&D Japan)

Abstract:

Due to a fast rise in the share of renewable energy with a corresponding destabilizing impact on the energy grid and a rapidly growing share of electric vehicles (EVs), the smart integration of electric mobility and facility energy management promises substantial social, ecologic, and economical benefits for drivers, facility and grid operators, and society in general. Vehicle-to-grid (V2G) technologies, which allow a bi-directional energy flow to and from the car, show an even greater potential. To investigate this potential in a company environment we have developed a smart charging manager that considers various objectives like peak load costs and users' charging requests to optimally control a number of uni-directional and bi-directional charging stations. Based on a prediction of the building's energy demand and Photo Voltaic (PV) production, an optimal charging plan is derived from a Mixed Integer Linear Programing approach. This work describes the main technical and algorithmic concepts and solution. We also present first results of some real-world tests in our facility.

20214348 **Evaluation of a modular system topology for large-scale wireless EVcharging in a commercial parking facility**
F3.3

Giuseppe Guidi[1], Salvatore D'Arco[1], Jon Are Suul[1,2] ([1]SINTEF Energy Research, [2]Norwegian University of Science and Technology)

Abstract:

This paper evaluates the operation of a modular transformer-less grid interface topology for large-scale wireless charging of electric vehicles (EVs) under a loading scenario for a commercial parking facility. The studied configuration is based on a Modular Multilevel Converter (MMC) topology where each module is supplying the wireless EV charger installed in one parking spot of a largescale charging infrastructure. Thus, the load distribution within this MMC-based topology depends on the location and charging demand of each EV. Furthermore, unbalanced loading imposes the need for introducing circulating currents to maintain stable operation of the topology. The additional losses caused by the circulating currents needed for load balancing are assessed for a realistic loading scenario during one day in a commercial parking facility. The presented numerical analysis identifies the impact on the conduction losses from an algorithm used to optimize the circulating current references. The resulting conduction losses are compared to an idealized case without need for balancing and to the continuous operation with constant circulating current corresponding to the worst-case load unbalance. Furthermore, the presented results identify the effect of the rated charging power on the loading scenario. The results show how operation with very low and unbalanced loading is causing high relative conduction losses. Thus, the studied MMC-based topology can be most effectively utilized in locations with a high average occupancy of the charging units or if active scheduling of the EV charging is introduced.

20214349 **Feasibility Study of Onboard PV for Passenger Vehicle Application**
F3.4 **- Influence of Vehicle Irradiance on Energy Balance of EV Energy Requirement and PV Generation -**

Toshio Hirota[1], Shuai Pei[1], Kimiyoshi Kobayashi[1], Yushi Kamiya[1], Satoru Maeshima[2], Keiichi Komoto[3] ([1]Waseda University, [2]EKO Instruments Co., Ltd., [3]Mizuho Research & Technologies, Ltd.)

Abstract:

On-board PV system was evaluated by a simulation model of the energy balance between the vehicle energy requirement and the onboard PV power generation. Influence of vehicle usage condition including driving and parking, weather and seasons on vehicle irradiance was analyzed based on vehicle test data of energy consumption and vehicle irradiance. Onboard PV has a potential to reduce well-to-wheel CO_2 emission, and the number of plug-in charging.

May 26 (Wed.)

G1 (Special Session): Wireless Power Transfer III **Room 1 (12:30-13:50)**

Chairs: Ryosuke Ota (Tokyo University of Science)
Keisuke Kusaka (Nagaoka University of Technology)

20214350 **UL 2750 for Wireless Power Transfer**
G1.1 **- Safety and Correlation with SAE J2954 and IEC 61980 -**
Joe Bablo, Ken Boyce (UL LLC)

Abstract:

This paper provides a breakdown of the content and technical approach of UL 2750, Safety of Wireless Power Transfer Equipment for Electric Vehicles. The paper will introduce the reader to this standard and its contents, explain how it is used to evaluate wireless power transfer equipment for certification in North America, and will explain the correlation to SAE J2954, Wireless Power Transfer for Light-Duty Plug-in/Electric Vehicles and Alignment Methodology.

20214353 **Unveil of High Efficient Transfer Mechanism and Noticeable Characteristic of Resonant Wireless Power Transfer**
G1.2 **Systems**
Atsuo Hatono (University Kuala Lumpur)

Abstract:

This paper describes an analysis of the high efficient transfer mechanism and the noticeable characteristic of the resonant wireless power transfer (WPT) systems. For this purpose, this paper traces energy flow including accumulated energy on a space. With the aid of this energy flow tracing, the transmitter loop current $\mathbf{I_T}$ and the receiver loop current $\mathbf{I_R}$ including the secondary currents driven by the accumulated energy are given by

$$\mathbf{I_T} = \frac{k^2 Q\, Q_2}{R(1+k^2 Q\, Q_2)} V \qquad \mathbf{I_R} = \frac{-jk\sqrt{Q\, Q_2}}{\sqrt{R R_2}\,(1+k^2 Q\, Q_2)} V$$

where k is the coupling coefficient, **R** is the resistance of the inductors, L is the inductance, C is the capacitance, and R2 is the resistance including the load RL, Q is the Q factor of the transmitter, Q2 is the Q factor of the receiver, V is the applied voltage. These results show that the energy is transmitted over a plurality of the frequency periods. This transfer requires the -90 degree lag behind of the receiver current. This is the noticeable characteristics of the resonant type.

20214352 **High-power and Long-distance transmission Using the Electric Field Resonance**
G1.3 *Kazuyoshi Hada, Daiki Obara, Hiroyuki Yamazaki, Akihiro Okudera, Mitsuru Masuda (Furukawa Electric Co., Ltd.)*

Abstract:

There is considerable interest in the Wireless Power Transfer (WPT) as a technology for charging an electric vehicle and a mobile equipment in a non-contact manner. We are conducting a study with the purpose of achievement of a wireless power transmission system using the electric field resonance. In this paper, we have achieved a 3-kW power transmission with the efficiency of 79.8% at the distance of 150 mm between couplers.

20214351 **Future Mobility with Wireless Power Technology**
G1.4 *Naoki Shinohara (Kyoto University)*

Abstract:

Intelligent transport systems (ITS) are the future of mobility. Wireless communication, remote sensing, and wireless power are crucial technologies for ITS. Wireless communication and remote sensing have been applied to automatic driving systems, and we can now receive information of a car's surroundings by remote sensing, and we communicate wirelessly in automatic driving systems. Wireless power transfer (WPT) is a necessity for automatic driving systems and future mobility. The types of WPT include inductive near-field and far-field WPT via microwaves. Recently, the inductive near-field WPT charger of 200 kW class power in 20 kHz has been applied in public electric buses in Europe and China. The far-field WPT via microwaves is studied in universities not only for wireless chargers but also for wireless power supplies for sensors in an electric car. Wireless power can be supplied to a farther distance in the far-field WPT compared with inductive near-field WPT. Wireless-powered drones with microwave technology are expected to be a novel form of mobility. In this paper, I will introduce the recent researches on far-field WPT via microwaves for electric cars and drones.

G2 (Special Session): Wireless Power Transfer IV — Room 1 (14:25-15:45)

Chairs: Naoki Shinohara (Kyoto University)
Giuseppe Guidi (Sintef Energy Research)

20214354 G2.1 **Novel Evaluation Method for Leakage Electromagnetic Field Using Coil Scaling Law for Wireless Power Transfer System for Electric Vehicle**

Hayato Sumiya[1,2], Eisuke Takahashi[1], Nobuhisa Yamaguchi[1], Keisuke Tani[1], Sakahisa Nagai[2], Toshiyuki Fujita[2], Hiroshi Fujimoto[2] ([1]DENSO CORPORATION, [2]The University of Tokyo)

Abstract:

A wireless power transfer system(WPT) for electric vehicles(EVs) needs to be evaluated in its leakage electromagnetic field (EMF). It is generally determined to be measured at 10 m point when the maximum rated power is transmitted between full-scale coils. In this paper, we propose a novel evaluation method of the EMF using a coil scaling law. During the development period, the mini-scale coils can be used to verify the leakage electromagnetic field, and the full-scale coil only needs to be finalized to ensure that it satisfies the regulations, thus shortening the verification time and reducing the cost. In order to realize the above, the conditions that enable equivalent evaluation of full-scale and mini-scale coils were derived.

20214357 G2.2 **Development of Short-Term High Magnetic Field Generator for Biological Evaluation against Wireless Power Transfer Systems for Electrical Vehicles**

Kazuki Matsubara, Munetaka Kanagawa, Keiji Wada, Yukihisa Suzuki (Tokyo Metropolitan University)

Abstract:

Recently, wireless power transfer (WPT) systems for electrical vehicles (EVs) are attracted as a charging method. However, biological effects due to the magnetic field generated by WPT systems are concerned. Therefore, development of magnetic field generator and evaluation of biological effects are required. This paper discusses the development of short-term high magnetic field generator to evaluate the biological effects due to magnetic field for 85 kHz band. Experimental verification with output current of 333.6 A_{rms} is presented. In addition, high reproducibility of experiment is confirmed from statistics of experimental results. In developed magnetic field generator, an average of induced internal electric field for mouse whole-body of 156.5 V/m is achieved, that is 6.82 times the basic restriction for occupational exposure of ICNIRP guideline.

20214355 G2.3 **Standardization of Exposure Assessment Methods of Wireless Power Transfer for Electric Vehicles**

Kanako Wake, Teruo Onishi, Masao Taki (National Institute of Information and Communications Technology)

Abstract:

A wireless power transfer (WPT) is a key technology for the wide-spread use of electric vehicles (EV). It is necessary to confirm human safety against the exposure to electromagnetic fields by EV-WPT for the wide-spread use. This paper describes recent standardization activities of exposure assessment of WPT for EVs discussed in the International Electrotechnical Commission (IEC).

20214356 G2.4 **Active Implantable Medical Device EMI Estimation for EV-Charging WPT System Based on Measurement and 3D Numerical Analysis**

Takashi Hikage (Hokkaido University)

Abstract:

Numerical evaluation of active implantable pacemaker EMI using a wireless power transmission system (WPT) for electric vehicle (EV) charging is presented. In this study, a numerical model consisting of an EV-WPT and a human body phantom was developed and used for the simulation. The interference voltage induced in the implantable pacemaker model was determined by a three-dimensional full-wave numerical simulation based upon the finite element method (FEM). To estimate the interference voltage in a conservative case, this study assumes an exposure scenario in which the human body's orientation and position are changed.

H1 (Special Session): Power Electronics Component and System Technologies — Room 2 (12:30-13:30)

Chairs: Hiromichi Imai (Honda Motor Co., Ltd.)
Satoshi Yasuda (TOYOTA MOTOR COPORATION)

20214358 H1.1 **Newly developed technologies of Power Control Unit for various electrified vehicles**

Toshio Ikeyama, Keisuke Yuki, Masaru Nakashima, Ryoji Hironaka (TOYOTA MOTOR CORPORATION)

Abstract:

Toyota Motor is developing new hybrid vehicles (HV) and plug-in hybrid vehicles (PHV) from compact class to medium class. It also plans to increase the ratio of electric vehicles (HV, EV, PHV, FCV) to 50% toward 2025.

For the next generation, we are efficiently developing PCUs suitable for the development of vehicles with various capacities and output, and adopting new technologies. For example, we adopted the reverse conduction IGBT (RC-IGBT) for the first time in the world to achieve minimization, weight reduction, and high efficiency. In this paper, we describe a technology that adapts to various output and realizes a compact, lightweight, and low-loss PCU and output for the next generation, and adopting new technologies.

20214359 **GEN3 Power Control Unit for Small Hybrid Vehicle**
H1.2 *Kenichi Takebayashi (Hitachi Astemo, Ltd.)*

Abstract:

This article introduces the 3rd generation PCU (GEN3-PCU) in a small size with low costs that has been newly developed for small-sized 2-motor hybrid vehicles HONDA FIT based on the GEN2-PCU.

20214360 **PWM control method to improve the voltage utilization rate of the inverter**
H1.3 *Takeshi Kuroda, Ryota Maeno, Akihiro Odaka (Fuji Electric Co., Ltd.)*

Abstract:

Inverters that drive in-vehicle motors are required to be driven efficiently and stably in a wide operating range from low-speed large torque to high-speed high-induced voltage. In order to improve the efficiency of the inverter, it is necessary to further reduce the output current for the same torque by improving the voltage utilization rate. In this paper, we propose a PWM control method that improves the voltage utilization rate of the inverter, and confirm its effectiveness by experiments.

H2 (Special Session): Power Semiconductor and Packaging Technologies — Room 2 (14:25-15:45)

Chairs: Shigeharu Yamagami (Nissan Motor Co., Ltd.)
Michiaki Hiyoshi (Hyundai Motor Japan R&D Center, Inc.)

20214361 **Design of Semiconductor/Insulator Interfaces in SiC Trench MOSFETs to Improve Power Efficiency of Electric/Hybrid**
H2.1 **Vehicles**
Katsuhiro Kutsuki, Yukihiko Watanabe (TOYOTA CENTRAL R&D LABS., Inc.)

Abstract:

This study demonstrates the factors limiting the channel mobility in SiC trench MOSFETs in order to improve the power efficiency of electric/hybrid vehicles. Previously proposed analysis methods of the channel mobility are adopted to evaluate the effects of the trench angle and surface morphology of trench sidewalls on the channel mobility. When the trench angle is close to 90°, the surface is atomically flat, or both are true, the channel mobility increases. The increase could be caused by the suppression of Coulomb scattering attributed to dangling bonds at SiC surface of trench sidewalls.

20214362 **1.2-kV Double-Sided Direct-Cooling Power Module for EV Traction Inverter**
H2.2 *Takeshi Tokuyama[1], Junpei Kusukawa[1], Nobutake Tsuyuno[1], Kei Suzuki[2] ([1]Hitachi, Ltd., [2]Hitachi Automotive Systems, Ltd.)*

Abstract:

We propose a new 1.2-kV double-sided direct-cooling power module (PM) that uses high thermal conductive insulation sheets. This PM uses two new insulation technologies. The first is a conductor laminated insulation sheet that divides the void voltage inside the insulation sheet to improve a partial discharge voltage compared with a conventional sheet. The second is a new power terminal insulation structure that uses a high comparative tracking index transfer molding resin. This new structure achieves a narrow space design of high voltage DC terminals for reducing stray inductance and enables faster switching speeds. We evaluate the performance of the developed PM, and the results prove its lower thermal resistance and stray inductance performance.

20214363 **High Performance and Reliable Si Power Devices with double side Cu plate**
H2.3 *Tatsuya Ohguro, Takako Motai, Hitoshi Kobayashi, Takuma Hara, Shinichi Umekawa (Toshiba Electronic Devices & Storage Corporation)*

Abstract:

In this work, we have developed vertical Si power MOSFETs with high performance and high reliability by using Cu double side plating technology. 20 μm thick Cu plating layers are formed on both sides of devices with 50 μm thick Si substrate. In this structure, even though Si substrate is thinner, Safety Operating Area (SOA) is wider and the warpage of chip is smaller thanks to front and back side thick Cu plating layers because thick Cu film has higher thermal conductivity and larger heat capacity.

20214364 **Effects of crystalline defects on degradation of SiC devices**
H2.4 *Masashi Kato (Nagoya Institute of Technology)*

Abstract:

Silicon carbide (SiC) metal oxide semiconductor field effect transistors (MOSFETs) are promising for power devices in electric and hybrid electric vehicles. However, at present, reliability of SiC MOSFETs is still an important issue to be solved. One of the origins for degradation of SiC MOSFETs performance is expansion of basal plane dislocations (BPDs) to single Shockley stacking faults (1SSF). The expansion of 1SSFs proceeds to the epitaxial layer of SiC MOSFETs and 1SSFs act as resistive components and degrade MOSFET performance, and thus we need to suppress the expansion of BPDs. In this paper, we report on carrier recombination lifetime in 1SSF and SiC epitaxial layers to find the suppression methods of 1SSF expansion.

I1: Energy Transmission Systems to Vehicles and Global Warming II — Room 3 (12:30-14:10)

Chairs: Yutaka Ota (Osaka University)
Nobuyoshi Okui (National Traffic Safety and Environment Laboratory)

20214365 **CharIN e.V. – Harmonization of a global EV charging standard from vehicle to grid to high power charging**
I1.1 *Claas Bracklo[1], Michael Keller[2], Jacques Borremans[3] ([1]BMW AG, [2]Volkswagen AG, [3]CharIN e.V. Asia.)*

Abstract:

Under the CharIN umbrella, cross-industry stakeholders like automakers, charging station manufacturers, component suppliers, energy providers, grid operators, and many others continue moving towards interoperable charging, where vehicles, chargers, and software systems work together and to make the user experience reliable, easy and smooth. CharIN´s holistic approach is not limited to passenger cars. Its international community is comprised of leading global companies representing every link to the e-mobility value chain and multiple experts who have been working together as a team to drive the requirements of charging all kinds of electric vehicles. Besides several further topics and activities, the scope has been extending to Commercial Vehicles and thus, setting requirements and standards for the development of the Megawatt Charging System (MCS). In the close future, the MCS shall also be used to charge other heavy-duty vehicles like e-ferries, ships, and planes. CharIN´s next goal is to define requirements for the evolution of CCS related standards and for the certification of CCS based products.

20214366 **Commercial Vehicle Predictive Cruise Control Algorithm Based on Dynamic Programming**
I1.2 *Yiran Ding, Yuhai Wang, Jianlong Hu (Jilin University)*

Abstract:

The algorithm in this paper is aimed at commercial vehicles driving on composite roads including slopes. During the driving process, the ADAS map obtains the slope information of the road ahead. Based on the principle of dynamic programming, a predictive cruise algorithm for economical driving on a ramp is designed, the torque is controlled by VCU. With fuel consumption and driving time cost as the system cost, the economical vehicle driving speed curve of a section of road ahead is obtained. The research results show that the predictive cruise algorithm can avoid the fuel waste caused by rapid acceleration during the uphill process, and make full use of the gravitational potential energy in the downhill process to be converted into kinetic energy for acceleration, effectively reducing fuel consumption.

20214367 **Online DC-driven Long-distance Heavy-duty Transportation System Based on Electric Highway System**
I1.3 *Gaoxin Bi, Yuhai Wang, Jianlong Hu, Lin Ma, Xiangyu Chen (Jilin University)*

Abstract:

With the continuous development of China's highway freight transport, the scale of highway freight transport continues to expand, which brings a series of problems, such as energy crisis, environmental pollution, cost increase and frequent traffic accidents. The scheme of online DC-driven long-distance heavy-duty transportation system based on electric highway system can fundamentally improve the social and economic problems caused by long-distance and heavy-duty logistics transportation relying on petroleum fuel . Smart catenary system, Intelligent hybrid truck and cloud control platform are the main components of DC-driven long-distance heavy-duty transportation system. Smart catenary system is the driving energy source of vehicles and the information exchange bridge between "person -vehicle- road- cloud". Intelligent hybrid truck receives the power transmitted by power catenary, senses the road and vehicle conditions in real time, uploads real-time data information to cloud control platform, and uses cloud control platform for leveling According to the energy management strategy of single-vehicle single-section optimization, multi-vehicle single-section optimization and multi-vehicle multi-section optimization, the power catenary energy and vehicle driving state are optimized and adjusted. Through the cooperation of smart catenary system, intelligent vehicle and cloud control platform, the safe, efficient and energy-saving operation of online DC-driven long-distance heavy-duty transportation system can be realized.

20214368 **Rule-Based Energy Management Strategy for Hybrid System of Heavy Commercial Vehicle**
I1.4 *Xiaozhi Li, Yuhai Wang, Jianlong Hu (Jilin University)*

Abstract:

This paper takes a heavy truck as the prototype, the vehicle is redesigned on the basis of the original power system, and it is transformed into a single-axle parallel hybrid electric vehicle to achieve lower fuel consumption and emissions, as well as better power performance. Considering the operating characteristics of heavy commercial vehicles, the components and parameters of the hybrid power system are determined at first. on this basis, a rule-based hybrid energy management strategy is established in Matlab/Simulink, and the energy management strategy is jointly simulated with the vehicle model built in Cruise. Finally, the dynamic performance and economic performance of the vehicle are simulated and verified, the results show that the rule-based hybrid energy management strategy for heavy commercial vehicles can significantly improve the fuel economy of the vehicle while ensuring the power of the vehicle.

20214369 **MAHLE Urban Mobility Concept**

I1.5 **- Design and Validation of a 48 V Urban Mobility Vehicle for the Future -**

Jonathan Hall[1], Daniel Rieger[2], Mike Bassett[1], Stephen Borman[1], Simon Reader[1], Martin Berger[2] ([1]MAHLE Powertrain Limited, [2]MAHLE International GmbH)

Abstract:

The current challenges for the automotive industry as well as the advancing urbanization lead to new mobility concepts and powertrain technologies. MAHLE developed a fully electric urban vehicle concept called MEET – MAHLE Efficient Electric Transport. It combines MAHLE's core competence and expertise in electric powertrains, thermal management, as well as climate comfort. Right at the start of the development key aspects of urban mobility were identified to determine the characteristics of MAHLE's urban vehicle concept. MEET gives an outlook for future mobility and it shows the holistic approach for an efficient system solution for the electrified urban mobility.

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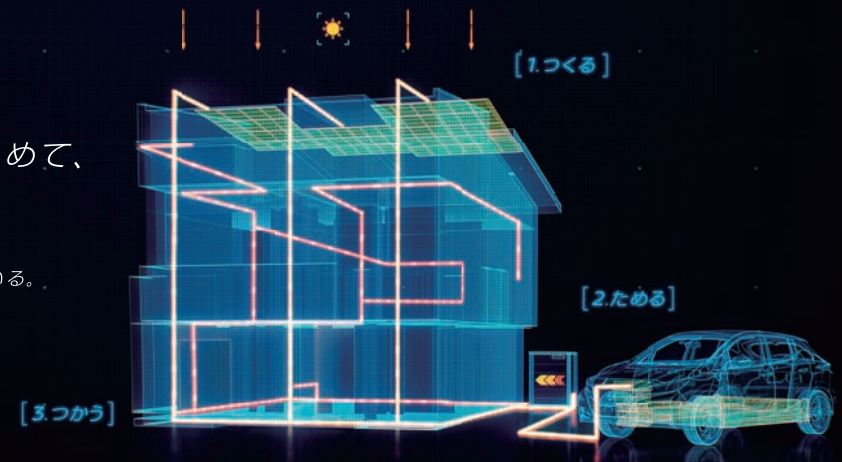

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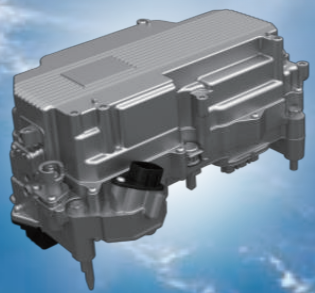
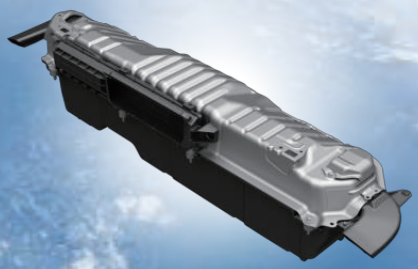


IPU

[Intelligent power unit]



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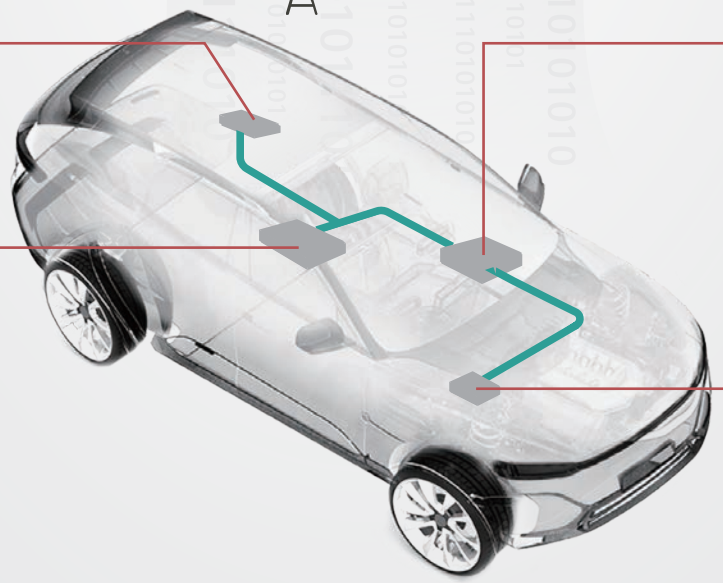

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MDC platform, toolchain, LiDARs, mmWave radars, cameras, and autonomous driving solution (ADS)

*MDC: Mobile Data Center

* OBC: on-board charger
BMS: battery management system
MCU: motor control unit
VDC: vehicle domain controller

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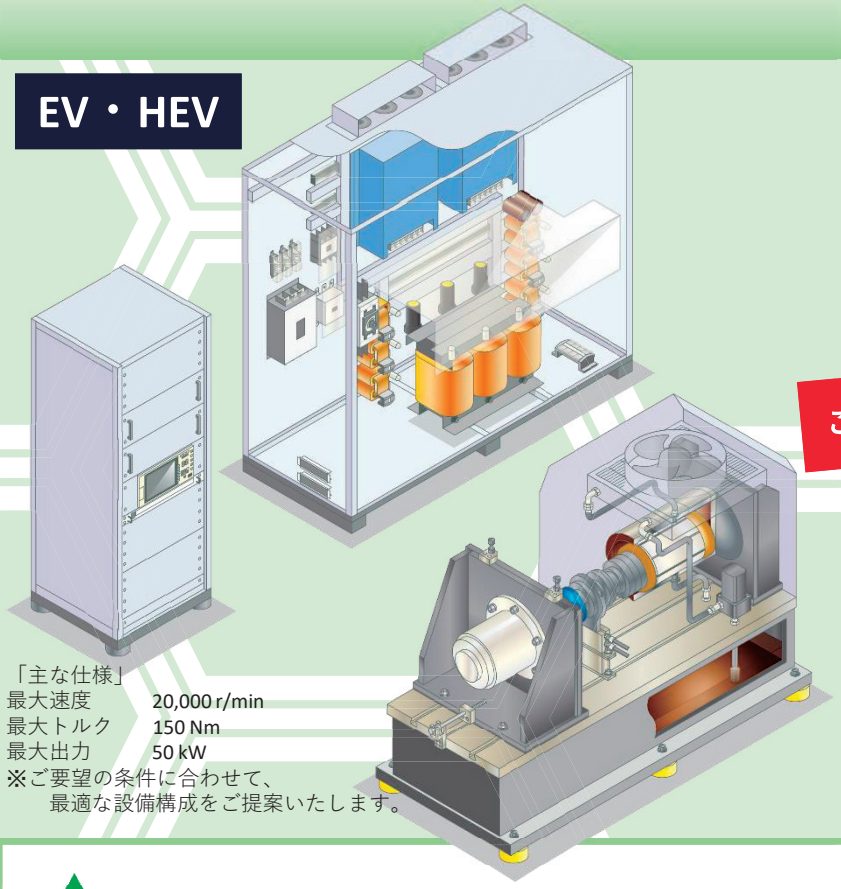

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ENGINEERING WHAT'S AHEAD / シミュレーションの力で未来を設計する

自動車の電動化において優位性を保つためには、
市場投入までの時間を短縮し、かつ従来の乗用車並みの
安全性・信頼性を担保しなければなりません。

次の設計課題は迅速に解決される必要があります。

ー 安全性：発熱対策、EMI/EMC、構造的な耐久性
ー 性能：航続距離、充電時間、バッテリー寿命
ー コスト：電費の改善、制御ソフトウェア開発費　など

Ansysは、流体、構造、電磁界、熱などの物理現象の連成解析から
組込み制御ソフトウェア設計・検証、最適化まで、広範な技術領域をカバーする
ソフトウェアツール群を提供します。

電気自動車に不可欠なバッテリーの形状/構造解析から、リアルタイム解析手法による
バッテリーパックの温度分布解析、実走シナリオを考慮した熱管理の最適設計など、
効率の最大化や、安全性・信頼性の検証をバーチャルにシミュレーションで実現します。

Ansysとともにシミュレーションの力で未来を設計しませんか？

Ansys

https://www.ansys.com/ja-jp

Aisan Group's Vision

VISION2030 Beaming future is in our hands

Our Goal

Creating new values with proven technology and quality to enrich society.
Making the present society more convenient and bringing happiness to future generations.

ESG Management

Social Value
Making society safe and enriching people's hearts

Environmental Value
Achieving the right balance between the environment and livability

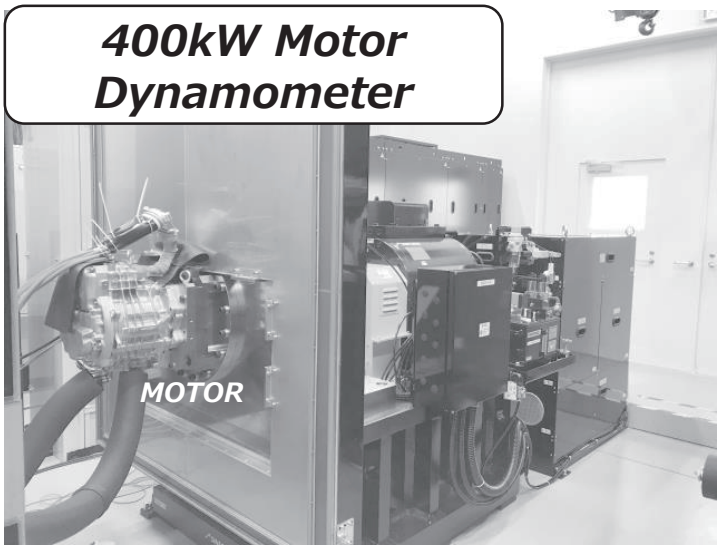
Economical Value
Maximizing the social value to grow continually

Aisan

www.aisan-ind.co.jp/en

Motor Performance Evaluation

400kW Motor Dynamometer



Supports Temperature Environment test

Constant Temperature Chamber

Motor Dynamometer	Rated Power	400kW/5457-20000min^{-1}
	Rated Torque	700Nm/0-5457min^{-1}
DC Power Supply		1000V,1000A
Inverter Emulator		1000V,1000A
ATF Cooler		-40～120℃
LLC Cooler		-40～110℃
Constant Temperature Chamber		-40～150℃

http://www.jari.or.jp/tabid/727/Default.aspx

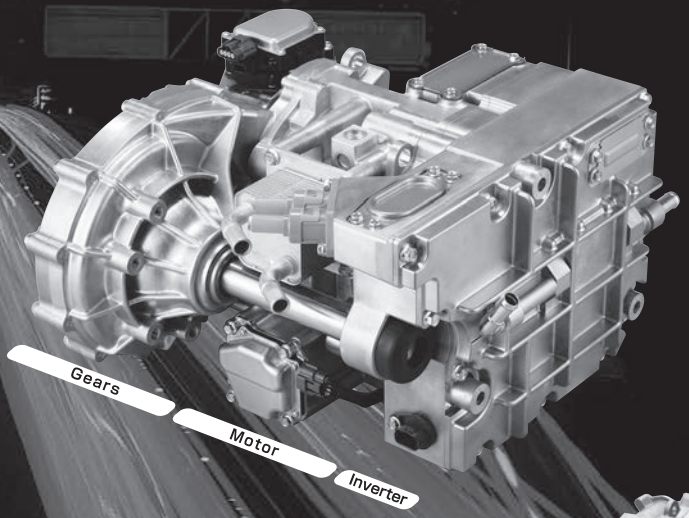
JARI
JAPAN AUTOMOBILE RESEARCH INSTITUTE

Three-in-one structure for compactness, lightness, and high output

MEIDEN
Quality connecting the next

Motor, inverter, and gears for electric vehicles integrated in a single unit

Performance can be increased by improving efficiency of vehicle space and reducing size and weight.



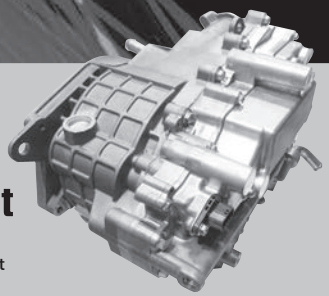
MEIDEN e-Axle

Maximum output 150 kW

Motor | Inverter | Gears Integrated unit

TECHNOLOGY	FUNCTION
■Maximum speed of 16,000 rpm	■60% increase in power density
■Rectangular wire coil	■100 kW continuous rated output
■Self-circulating oil-cooled motor	■280 mm thin size
■Axial arrangement of inverter	■78 kg weight of unit

Lineup of units that can be equipped to various vehicle models



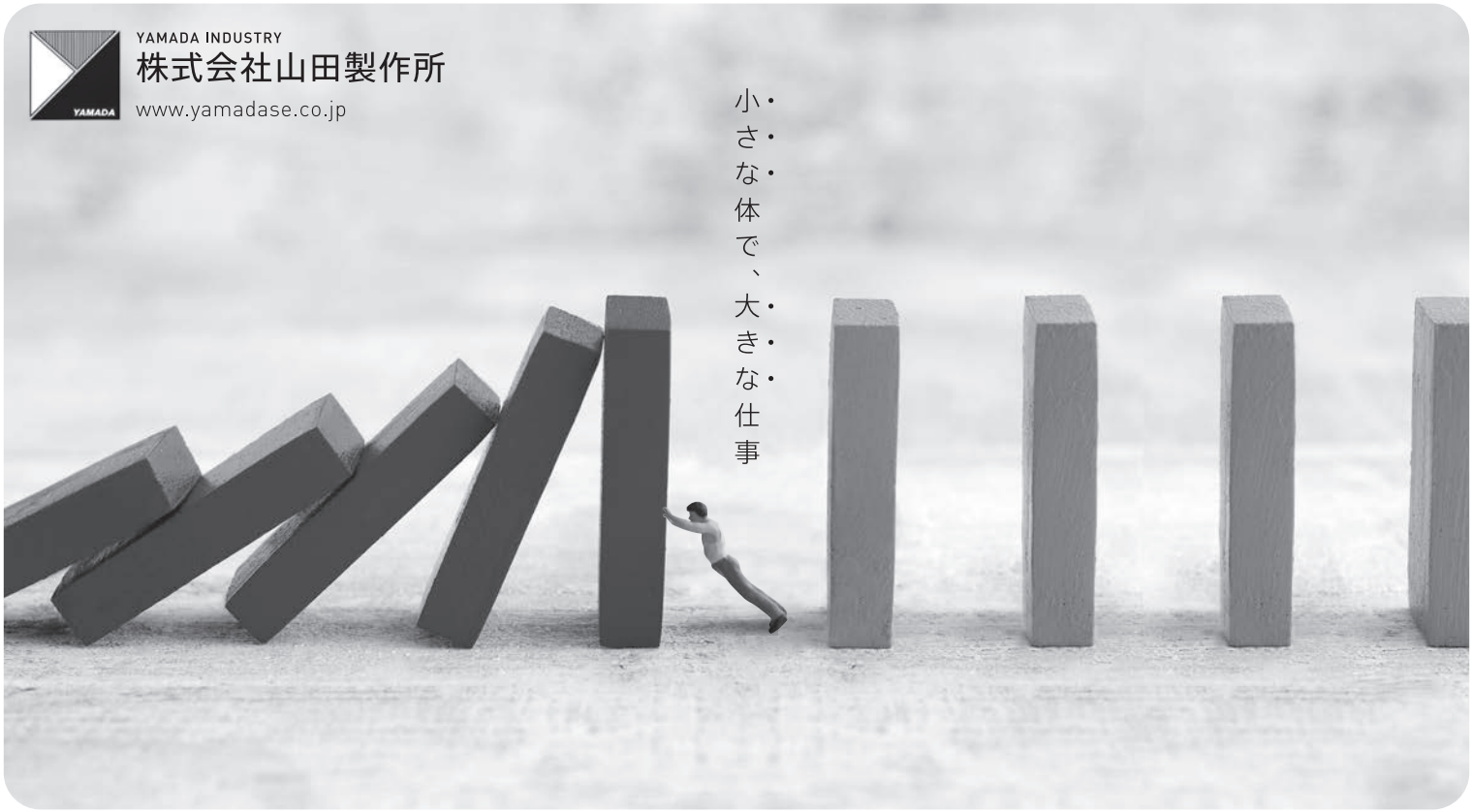
MEIDEN Drive Unit

Maximum output 100 kW

Motor | Inverter Integrated unit

MEIDENSHA CORPORATION ThinkPark Tower, 2-1-1, Osaki, Shinagawa-ku, Tokyo, 141-6029 Japan

YAMADA INDUSTRY
株式会社山田製作所
www.yamadase.co.jp



/E/V/社/会/を/ひ/ら/く/、 非金属プレス

絶縁体である樹脂をはじめ、非金属素材をプレス加工

CAPACITORS FORUM
キャパシタフォーラム

The Capacitor Forum was established in April 2005 for the purpose of improving and promoting the application of energy storage technology using high-capacity capacitors such as electric double-layer capacitors and lithium-ion capacitors.
Currently, with Dr. Yoichi Hori, who advocates the concept of "motor/capacitor/wireless" as chairman, the forum has members (27 corporations and 33 individuals) from a wide range of fields, including not only capacitor manufacturers but also manufacturers of materials and applied applications, universities, and research institutes, and conducts activities such as annual conferences, monthly forums, publication of newsletters, exchanges with overseas countries, and domestic and international technical surveys.

About http://capacitors-forum.org/ Contact zimukyoku@capacitors-forum.org