Applied Power Electronics Conference

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MARCH 17-21 | ANAHEIM, CA.

ANAHEIM CONVENTION CENTER

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APEC MOBILE APP

Download the APEC 2019 mobile app to access the latest event updates and information, including session speaker information, exhibitor seminars and exhibitor list and locations, timely notifications such as cancellations and room changes, event reminders, and more. The app is accessible through Google Play (Android) and Apple Store (IOS devices) by searching **'APEC IEEE Applied Power Electronics'** or **'APEC 2019'**.

WI-FI

Wi-Fi is available throughout the Convention Center. Once connected, open your web browser and follow the prompt to input a password.

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APEC: Applied Power Electronics Conference

APEC: Applied Power Electronics Conference

FOREWORD

It is my honor and pleasure to welcome you to Anaheim and the 34th annual IEEE Applied Power Electronics Conference and Exposition (APEC 2019).

APEC has a long-standing history of providing theoretical and application-oriented learning opportunities through a variety of educational sessions, including Professional Education Seminars, technical papers presented in lecture and dialog sessions, application-oriented Industry Sessions, thought provoking RAP Sessions, and extensive Exposition and Exhibitor Seminars. This comprehensive blend has branded APEC the ***Premier Event in Applied Power Electronics***.

One of the best aspects of APEC is the opportunity to expand your professional network, make new connections, and reconnect with peers, friends, and colleagues. This year, you'll have the opportunity to do so through various social happenings including Monday's Welcome Reception, Wednesday's Evening Social, during breaks and lunches in the Exhibit Hall, as well as Dialogue Sessions.

Each year, APEC is made possible through the tireless effort of its all-volunteer organizing committee and the three sponsoring organizations: Power Sources Manufacturers Association (PSMA), and the IEEE Power Electronics Society (PELS) and Industry Applications Society (IAS). It is their combined dedication, expertise, and support, along with our professional conference management partner, SmithBucklin, which drives the success of this conference as a showcase of the latest advances in power electronics.

Most importantly, the continued success of APEC is due to the support of attendees like you, our exhibitor and sponsors, and volunteer teams. It is your passion and knowledge that makes APEC a memorable event that continues to grow and evolve year after year. I look forward to meeting you during these next few days and sharing in this experience with you.

Ernie Parker
General Chair
2019 IEEE Applied Power Electronics Conference and Exposition

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SCHEDULE-AT-A-GLANCE

SUNDAY, MARCH 17

	Time	Location
Registration	8:00 a.m. – 5:00 p.m.	Expo Hall D
Speaker Breakfast	8:00 a.m. – 9:00 a.m.	Ballroom E
Professional Education Seminars (concurrent sessions) *see page 15 for full details*	9:30 a.m. – 1:00 p.m.	2nd and 3rd Floors
Break	1:00 p.m. – 2:30 p.m.	Foyer
Professional Education Seminars (concurrent sessions) *see page 17 for full details*	2:30 p.m. – 6:00 p.m.	2nd and 3rd Floors

MONDAY, MARCH 18

Registration	7:00 a.m. – 6:00 p.m.	Expo Hall D
Speaker Breakfast	7:00 a.m. – 8:00 a.m.	Ballroom E
Spouse and Guest Breakfast	8:00 a.m. – 10:00 a.m.	Anaheim Marriott, Elite Ballroom 3
Professional Education Seminars (concurrent sessions) *see page 19 for full details*	8:30 a.m. – 12:00 p.m.	2nd and 3rd Floors
Lunch	12:00 p.m. – 1:00 p.m.	*On your own*
Opening Plenary Session	1:00 p.m. – 5:00 p.m.	Ballroom ABCD
Welcome Reception	5:00 p.m. – 8:00 p.m.	Expo Hall D
MicroMouse Contest	8:00 p.m. – 10:00 p.m.	Expo Hall D

TUESDAY, MARCH 19

Registration	7:00 a.m. – 5:00 p.m.	Expo Hall D
Speaker Breakfast	7:00 a.m. – 8:00 a.m.	Ballroom E
Spouse and Guest Breakfast	8:00 a.m. – 10:00 a.m.	Elite Ballroom 1, Anaheim Marriott
Technical Sessions (concurrent sessions) *see page 26 for full details*	8:30 a.m. – 10:10 a.m.	2nd and 3rd Floors
Industry Sessions (concurrent sessions) *see page 23 for full details*	8:30 a.m. – 11:55 a.m.	2nd Floor
Break	10:00 a.m. – 10:40 a.m.	Foyer
Technical Sessions (concurrent sessions) *see page 26 for full details*	10:40 a.m. – 12:00 p.m.	2nd and 3rd Floors
Exhibit Hall Open	12:00 p.m. – 5:00 p.m.	Expo Hall D
Lunch	12:00 p.m. – 1:30 p.m.	Expo Hall D
Exhibitor Seminars #1 (concurrent sessions)	1:30 p.m. – 2:00 p.m.	2nd and 3rd Floors, Expo Hall D
Exhibitor Seminars #2 (concurrent sessions)	2:15 p.m. – 2:45 p.m.	2nd and 3rd Floors, Expo Hall D
Break	2:45 p.m. – 3:15 p.m.	Expo Hall D
Exhibitor Seminars #3 (concurrent sessions)	3:00 p.m. – 3:30 p.m.	2nd and 3rd Floors, Expo Hall D
Exhibitor Seminars #4 (concurrent sessions)	3:45 p.m. – 4:15 p.m.	2nd and 3rd Floors, Expo Hall D
RAP Sessions (concurrent sessions) *see page 32 for full details*	5:00 p.m. – 6:30 p.m.	Ballroom B, C, D

SCHEDULE-AT-A-GLANCE

WEDNESDAY, MARCH 20

	Time	Location
Registration	7:00 a.m. – 2:00 p.m.	Expo Hall D
Speaker Breakfast	7:00 a.m. – 8:00 a.m.	Ballroom E
Spouse and Guest Breakfast	8:00 a.m. – 10:00 a.m.	Elite Ballroom 1, Anaheim Marriott
Technical Sessions (concurrent sessions) *see page 45 for full details*	8:30 a.m. – 10:10 a.m.	2nd and 3rd Floors
Industry Sessions (concurrent sessions) *see page 41 for full details*	8:30 a.m. – 11:55 a.m.	2nd Floor
Break	10:10 a.m. – 10:40 a.m.	Expo Hall D
Exhibit Hall Open	10:00 a.m. – 2:00 p.m.	Expo Hall D
Exhibitor Seminars #5 (concurrent sessions)	10:30 a.m. – 11:00 a.m.	2nd and 3rd Floors, Expo Hall D
Exhibitor Seminars #6 (concurrent sessions)	11:15 a.m. – 11:45 a.m.	2nd and 3rd Floors, Expo Hall D
Exhibitor Seminars #7 (concurrent sessions)	12:00 p.m. – 12:30 p.m.	2nd and 3rd Floors, Expo Hall D
Lunch	12:30 p.m. – 2:00 p.m.	Expo Hall D
Technical Sessions (concurrent sessions) *see page 48 for full details*	2:00 p.m. – 3:40 p.m.	2nd and 3rd Floors
Industry Sessions (concurrent sessions) *see page 42 for full details*	2:00 p.m. – 5:25 p.m.	2nd Floor
Break	3:40 p.m. – 4:10 p.m.	Breakout Foyers
Technical Sessions (concurrent sessions) *see page 45 for full details*	4:10 p.m. – 5:30 p.m.	2nd and 3rd Floors
Social Event	6:00 p.m. – 9:00 p.m.	Grand Plaza

THURSDAY, MARCH 21

Speaker Breakfast	7:00 a.m. – 8:00 a.m.	Ballroom E
Spouse and Guest Breakfast	8:00 a.m. – 10:00 a.m.	Platinum 7, Anaheim Marriott
Technical Sessions (concurrent sessions) *see page 62 for full details*	8:30 a.m. – 10:10 a.m.	2nd and 3rd Floors
Industry Sessions (concurrent sessions) *see page 59 for full details*	8:30 a.m. – 10:10 a.m.	2nd Floor
Break	10:10 a.m. – 10:35 a.m.	Foyer
Technical Sessions (concurrent sessions) *see page 62 for full details*	10:35 a.m. – 11:15 a.m.	2nd and 3rd Floors
Industry Sessions (concurrent sessions) *see page 59 for full details*	10:35 a.m. – 11:25 a.m.	2nd Floor
Dialogue Sessions and Lunch	11:15 a.m. – 1:45 p.m.	Ballroom
Technical Sessions (concurrent sessions) *see page 66 for full details*	1:45 p.m. – 3:25 p.m.	2nd and 3rd Floors
Industry Sessions (concurrent sessions) *see page 61 for full details*	1:45 p.m. – 3:25 p.m.	2nd Floor
Break	3:25 p.m. – 3:40 p.m.	Foyer
Technical Sessions (concurrent sessions) *see page 66 for full details*	3:40 p.m. – 5:00 p.m.	2nd and 3rd Floors

GENERAL INFORMATION

CONFERENCE REGISTRATION

All attendees must be registered for the conference. Prepaid conference registration is required for educational seminars, presentation sessions and dialogue sessions. To register or pick up conference materials, visit the APEC Registration Center at the Expo Hall. Please note that Technical Sessions including Dialogue and Lecture Sessions, Industry Sessions, and Professional Education Seminars are only available to specific registration types (Full Conference registration is required to attend all session types, Technical Sessions registration is required to only attend Technical and Industry Sessions, and Seminars Only registration is required to only attend the Professional Education Seminars).

Registration Hours:

Saturday, March 16. . . . . 4:00 p.m. – 7:00 p.m.
Sunday, March 17 . . . . . 8:00 a.m. – 5:00 p.m.
Monday, March 18 . . . . . 7:00 a.m. – 6:00 p.m.
Tuesday, March 19 . . . . . 7:00 a.m. – 5:00 p.m.
Wednesday, March 20 . . . . . 7:00 a.m. – 2:00 p.m.

APEC EXPOSITION

The Exposition will open on Monday, March 18 when the Plenary Session concludes.

Exposition Hours

Monday, March 18 . . . . . 5:00 p.m. – 8:00 p.m.
Tuesday, March 19 . . . . . 12:00 p.m. – 5:00 p.m.
Wednesday, March 20 . . . . . 10:00 a.m. – 2:00 p.m.

Admission

Entry is granted to persons 18 or older with any APEC badge, including the free "Exhibit Hall" badge which also grants admission to the exhibitor seminars, plenary session, MicroMouse contest and RAP sessions.

Exposition Lunch and Breaks

Lunch will be served in the Exhibit Hall on Tuesday from 12:00 p.m. – 1:30 p.m. and on Wednesday from 12:30 p.m. – 2:00 p.m. free of charge to all who have access to the exhibit hall. Lunch will be on your own on Sunday and Monday. The Tuesday afternoon coffee break will be in Exhibit Hall from 2:45 p.m. – 3:15 p.m. The Wednesday morning coffee break will be served in the Exhibit Hall from 10:00 a.m. – 10:30 a.m.

Exposition Giveaway

During all three days of the Exposition we will be giving out prizes. At registration, everyone (Exhibit Hall registrants and exhibitors included) will be issued a raffle ticket that you will put in a drop box located in APEC HUB (Booth 539). This will be good for all three days of raffles during the exposition.

MATERIALS PURCHASE

Purchase of Conference Proceedings and Seminar Workbooks

Only copies on USB of the APEC Proceedings will be provided with the Full or Technical Sessions registration. Conference registrants can purchase extra copies of the Conference Proceedings and Seminar Workbooks on USB through Early Registration. APEC reserves the right to limit quantities of APEC Proceedings or Seminar Workbooks sold to any one person or institution.

Conference Proceedings and Seminars on USB Payment Policy

For payments at the conference, APEC can accept credit cards (Master Card, Visa or American Express), checks, or money orders (payable in U.S dollars and drawn on a U.S. bank). Checks and money orders returned unpaid will be assessed an additional handling charge of $50.00 USD. A limited number of copies of the Conference Proceedings and Seminar Workbooks may be available for sale at registration starting at noon on Sunday, March 17.

On-site Purchase

> **Conference Proceedings (USB Only):** $205.00 USD

> **Seminar Workbook (USB only):** $205.00 USD

Publications purchased can be picked up at the registration desk.

Purchasing through the IEEE

Post conference APEC Proceedings may be purchased through the IEEE.

IEEE Single Copy Sales

445 Hoes Lane
Piscataway, New Jersey 08854, USA
P: (800) 678-4333 (USA & Canada) or (732) 981-0060
Website: http://shop.ieee.org/ieeestore/

IMPORTANT RULES, NOTICES, AND CONFERENCE POLICIES

Badges Required for Admission

Badges are required for admission to all APEC events and activities. Badges are obtained by registering with the conference. APEC reserves the right to deny admission to any APEC event or activity to any person not showing an appropriate badge for that activity or event.

Recording and Photography

Attendee Recording/Photography: Video and audio recording may be conducted in the Exhibit area, the MicroMouse contest, and public areas of APEC, but nowhere else except with written permission from the Conference Chair. Still photography at APEC is permitted, but with limitations. The general principle is that people may be photographed but photographing presentations and other content is prohibited unless permission from the speaker(s) is obtained in advance. For more details, please see Show Management.

APEC Photography for Marketing Purposes: By registering for APEC 2019, you agree that any photos taken of you while at the conference by our professional photographer may be used by APEC in the future.

Showcasing/Suitcasing Policy

Please note that while all meeting attendees are invited to the showcase, any attendee who is observed to be soliciting business in the aisles or other public spaces, in another company's booth, or in violation of any portion of the Exhibition Policy, will be asked to leave immediately. Additional penalties may be applied. Please report any violations you may observe to Show Management. Show Management recognizes that suitcasing may also take the form of commercial activity conducted from a hotel guest room or hospitality suite; a restaurant, club, or any other public place of assembly. For the purposes of this policy, suitcasing violations may occur at venues other than the exhibition floor and at other events. Show Management must be informed of any hospitality suites, and expressed consent must be received prior to the event.

Recruitment Policy

IEEE Policy #10.1.24 prohibits recruiting at IEEE sponsored conferences. Consequently, recruiters and recruiting advertisements will not be permitted in the APEC 2019 hotel space, meeting facilities or Exhibit Hall.

Distribution of Commercial Material at APEC

Rules for Non-Exhibitors: Distribution of commercial material in the APEC 2019 hotel space (including directly to the hotel rooms of APEC participants), meeting space and Exhibit Hall by people or organizations not participating in the Exposition is prohibited. APEC reserves the right to remove without notice any materials not in compliance with this policy.

Rules for Exhibitors: Exhibitors may only distribute commercial materials in their booth, at Exhibitor Seminars they are conducting and at press conferences they are holding. APEC reserves the right to remove without notice any materials not in compliance with this policy.

Privacy Policy

Information Provided During Registration: Contact information, which includes your name, affiliation, and mailing address, may be provided upon request to any partners and/or supporting publication participating in the APEC 2019 Exposition. In addition, APEC may use the information you provide to contact you with information about APEC 2019 or any future APEC events. No other use will be made of the information you provide. Your information will not be sold, distributed, leased or provided to any other person or organization except as described above.

Information Provided Other than Through Registration: People who provide their names to APEC through the APEC website, direct contact, digest submission, volunteering to review, or in any way other than registering for the conference, will not have their names and contact information distributed to anyone or any organization, including APEC's sponsors. APEC will use the contact information only for transmitting information related to APEC. Conference registrants' names and contact information, including name, affiliation, and mailing address will be provided to exhibitors and media partners. Emails will only be provided to exhibitors through the Lead Retrieval systems used on the show floor. Registering for APEC gives permission for your name and contact information to be provided to exhibitors and media partners and for exhibitors and media partners to contact you during or after the conference. APEC will not otherwise distribute names and contact information received through the registration process.

2019 IEEE WILLIAM E. NEWELL POWER ELECTRONICS AWARD

Sponsored by the IEEE Power Electronics Society

PATRIZIO VINCIARELLI

For visionary leadership in the development of high-efficiency, high-power-density power conversion components for distributed power system applications.

The award presentation will take place during the Plenary Session on Monday, March 18 beginning at 1:00 p.m.

About Patrizio Vinciarelli

Smaller and more efficient power modules have accelerated the evolution of distributed power architectures, enabling power systems with higher efficiency, power density, and other key performance attributes. Patrizio Vinciarelli's patented contributions led to new power distribution architectures, Zero-Current Switching (ZCS) and Zero-Voltage Switching (ZVS) power conversion topologies, and advanced power packaging. His Factorized Power Architecture (FPA) leveraged current multiplication modules that can efficiently deliver hundreds of amperes at voltages less than 1 V. His Converter Housed in Package (CHiP) scalable packaging technology has enabled higher levels of power system efficiency and density. Vinciarelli holds 151 U.S. patents. Vinciarelli is the founder and chief executive officer of Vicor Corporation, Andover, MA, USA.

About the William E. Newell Power Electronics Award

The IEEE William E. Newell Power Electronics Award was established in 2005. It was established in memory of William E. Newell of the Westinghouse Research and Development Center in Pittsburgh, Pennsylvania. Recipient selection is administered through the Technical Field Awards Council of the IEEE Awards Board.

INFORMATION FOR SPEAKERS

PROFESSIONAL EDUCATION SEMINAR SPEAKERS:

Breakfast will be provided for you the morning of your presentation. You should attend the breakfast only on the morning of your seminar. During breakfast, you will receive brief instructions from the Professional Education Seminar Chairs.

Professional Education Seminar Speaker Breakfast
Sunday at 8:00 a.m.; Monday at 7:00 a.m. | Ballroom E

INDUSTRY SESSIONS AND LECTURE TECHNICAL SESSION SPEAKERS:

You must attend a mandatory breakfast on the morning of your session. The Program Chair will host this breakfast at which you will be given your speaker ribbon and provided instructions. Immediately after breakfast you will be able to review your previously uploaded presentation with your session chair.

Industry and Lecture Technical Session Speaker Breakfast
Tuesday-Thursday at 7:00 a.m. | Ballroom E

DIALOGUE TECHNICAL SESSION SPEAKERS:

You must attend a mandatory breakfast on the morning of your session. During breakfast, you will receive brief instructions and will be able to mount your presentation on the poster boards in the room next door after the breakfast. Thumb tacks will be provided.

Dialogue Technical Session Speaker Breakfast
Thursday at 7:00 a.m. | Ballroom E

SPEAKER READY ROOM

Room 213A
Sunday 8:00 a.m. – 6:00 p.m.
Monday 7:00 a.m. – 1:00 p.m.
Tuesday 7:00 a.m. – 5:00 p.m.
Wednesday 7:00 a.m. – 4:30 p.m.
Thursday 7:00 a.m. – 4:00 p.m.

The Speaker Ready room will be available to all speakers should you need to review your presentation in advance of your session or make any edits.

SPECIAL EVENTS

SATURDAY, MARCH 16

PSMA MEETINGS

Power Magnetics at High Frequency

Saturday, March 16, 2019 | 7:00 p.m. – 6:00 p.m.
Room 304

The target audience for this workshop is all who wish to achieve higher power densities, low profile aspect ratio, higher efficiencies, and improved thermal performance. The workshop content is especially suitable for designers of power magnetic components, manufacturers of magnetic materials and magnetic structures, fabricators of magnetic components, providers of modelling and simulation software, manufacturers of test and characterization equipment. The workshop will consist of morning (ac power losses) and afternoon (thermal considerations for magnetic design) technical sessions and a lunchtime interactive technology demonstration session. The two technical lecture presentation sessions will each be followed by a panel Q&A. The technology demonstrations will also be available during the breakfast prior to the opening session and during the networking session at the end of the day's events.

The Impact of Wideband Technologies on Application of Capacitors – A Deep Dive on Capacitor Technology

Saturday, March 16, 2019 | 7:00 p.m. – 6:00 p.m.
Ballroom E

This day-long workshop will consist of morning and afternoon technical lecture presentation sessions and a lunchtime interactive technology demonstration session. Navitas Semiconductor will open the morning session with a keynote presentation on GaN technologies and its requirements on capacitors. Market-leading capacitor suppliers including KEMET, CDE, Panasonic, Faratronic and Wurth Electronics together with preeminent lecturers from universities around the world will discuss technical options and alternatives to meet the challenging requirements.

The "Technology Demonstrations" will be coincident with the luncheon period and will include interactive technology displays and/or presentations each addressing specific technical disciplines and capabilities consistent with the workshop agenda.

MONDAY, MARCH 18

SPOUSE AND GUEST ACTIVITIES

APEC welcomes the spouses and guests of APEC registrants to participate in conference activities. Transportation to and from each activity will be provided from the front lobby of the Anaheim Marriott following the Spouse and Guest Breakfast. This year's options include:

Newport Beach Lunch Cruise

Monday, March 18, 2019 | 10:00 a.m. – 2:30 p.m.

Have you been wanting to experience a boat ride tour in Newport Beach? Hornblower's Newport Harbor tour adventures offer opportunities to soak in the sunshine, shoot photos of historical landmarks and marvel at exclusive waterfront estates. You'll also spot marine animals and soaring seabirds, making this the most enticing sightseeing and wildlife watching around all whilst enjoying a delicious lunch on the water.

> Cost: $125 per person

MICROMOUSE CONTEST

Monday, March 18 | 8:00 p.m. | Expo Hall D

Enter the annual APEC MicroMouse contest or join us as a spectator for this exciting event. Participants design, build, and program robotic mice and compete to see who can navigate their way through the maze in the shortest time. The rules for the contest use a scoring system with a penalty for the time taken to map and run the maze, and a bonus for not touching the mouse. They are similar to those used at the IEE World Final held in London in 1987 except that the touch penalty has been reduced from 10 seconds to 2 seconds. The time for each contestant has also been reduced from 15 to seven minutes. Within this time limit, the MicroMouse may make up to five runs. Only one mouse per handler will be allowed this year.

Trophies and cash prizes will be awarded in the following categories based on score:

1st Place: $500 | 2nd Place: $250 | 3rd Place: $125

Trophies and cash prizes will be awarded to students in the following categories:

Best Student (based on score): $500
Fastest Run (based on run time): $150

MONDAY, MARCH 18 *(Continued)*

IEEE POWER ELECTRONICS SOCIETY MENTORING ROUND TABLES EVENT

Monday, March 18 | 7:00 p.m. – 9:30 p.m. | Ballroom E (3rd Floor)

The IEEE Power Electronics Society ("PELS") invites you to attend this casual round table dinner as part of its mentorship program for members of all ages. Advance registration plus a $10 fee to defray the costs of the event are required. For more information, contact Donna Florek, CMP, PELS Staff at d.florek@ieee.org.

TUESDAY, MARCH 19

SPOUSE AND GUEST ACTIVITIES

APEC welcomes the spouses and guests of APEC registrants to participate in conference activities. Transportation to and from each activity will be provided from the front lobby of the Anaheim Marriott following the Spouse and Guest Breakfast. This year's options include:

Fullerton Arboretum & Heritage House Tour

(LUNCH INCLUDED)

Tuesday, March 19, 2019 | 9:00 a.m. – 2:00 p.m.

Join one of our knowledgeable docents as they guide you on a tour through the beautiful garden. Enjoy the sights and sounds of our different garden collections through secret trails off the beaten path. Docents will take you to their favorite places in the garden and share stories and folklore. Bring your walking shoes and your enthusiasm!

> Cost: $125 per person

YOUNG PROFESSIONALS & STUDENTS RECEPTION

Tuesday, March 19 | 7:00 p.m. – 10:00 p.m.
Ralph Brennan's Jazz Kitchen
1590 Disneyland Dr, Anaheim, CA 92802

All Young Professionals and Students Welcome.
Sponsored by IEEE PELS and IEEE IAS

Power Electronics Society (PELS) and IEEE Industry Application Society (IAS) invite you to learn from the life journey of the biggest leaders at APEC along with an evening well-spent talking to people from across the globe. Don't miss this opportunity to make new friends and meet new people. Please visit http://bit.ly/2rNjQFQ for more information.

WEDNESDAY, MARCH 20

WEDNESDAY EVENING RECEPTION

Wednesday, March 20 | 6:00 p.m. – 9:00 p.m.
Anaheim Convention Center, Grand Plaza

APEC 2019 Full Conference and Technical Session registrants will receive a social event ticket with their registration. If you have a Seminar-Only or Exhibits-Only registration or are registered as an exhibitor, you may purchase a social event ticket by visiting the registration desk. You may also purchase tickets for your guest to attend. Exhibiting companies will receive a social event ticket with their conference registration.

SPONSOR MEETINGS

Please note: All meetings on this page are located at the Marriott.

IAS MEETINGS

SUNDAY, MARCH 17	Time	Location
Board Meeting	8:00 a.m. – 5:00 p.m.	Elite 2 & 3
MONDAY, MARCH 18		
Board Meeting	8:00 a.m. – 12:00 p.m.	Elite 2 & 3

IEEE PELS MEETINGS

SUNDAY, MARCH 17	Time	Location
International Electrotechnical Comission TC51	8:00 a.m. – 6:00 p.m.	Platinum 2
International Future Energy Challenge (IFEC) Workshop	8:00 a.m. – 6:00 p.m.	Platinum 3
Empower a Billion Lives (EBL) Leadership Meeting *(Members Only)*	11:00 a.m. – 2:55 p.m.	Platinum 4
PELS Exec Team Pre-Strategy Meeting *(Officers Only)*	3:00 p.m. – 5:00 p.m.	Platinum 4
MONDAY, MARCH 18		
International Electrotechnical Comission TC51	8:30 a.m. – 12:00 p.m.	Platinum 8
ECCE 2019 Organizing Committee Meeting	9:00 a.m. – 10:00 a.m.	Platinum 7
Energy Access Working Group and Empower a Billion Lives	9:00 a.m. – 10:30 a.m.	Platinum 3
PELS Membership Committee	9:00 a.m. – 12:00 p.m.	Platinum 4
PELS Fellows Committee	9:30 a.m. – 11:00 a.m.	Platinum 2
FEPPCON Steering Committee	10:00 a.m. – 11:00 a.m.	Platinum 7
PELS TC & Academic Chairs Lunch	11:30 a.m. – 1:00 p.m.	Platinum 2
PELS Chapter Chair Forum	11:30 a.m. – 1:00 p.m.	Platinum 4
Mentoring Round Tables *(Separate Pre-Registration Required)*	7:00 p.m. – 9:30 p.m.	Ballroom E
TUESDAY, MARCH 19		
PELS TC1 Power and Control Core Technologies	8:30 a.m. – 10:30 a.m.	Platinum 8
PELS Awards Committee	9:00 a.m. – 10:00 a.m.	Platinum 4
SPEC Steering Committee	9:00 a.m. – 10:00 a.m.	Platinum 3
IEEE Journal of Emerging and Selected Topics on Power Electronics (JESTPE) Steering Committee	9:00 a.m. – 10:00 a.m.	Platinum 7
PELS Mentorship Committee Meeting	10:00 a.m. – 10:55 a.m.	Platinum 2
IEEE Journal of Emerging and Selected Topics on Power Electronics (JESTPE) Editorial Board	10:00 a.m. – 12:00 p.m.	Platinum 7
PELS Day Planning Committee	11:00 a.m. – 12:00 p.m.	Platinum 4
PELS TC7 Communication Energy Systems	11:00 a.m. – 12:00 p.m.	Platinum 2
PELS Digital Media/Education	1:00 p.m. – 2:00 p.m.	Platinum 8
CPSS Transactions on Power Electronics and Applications Editorial Board	1:00 p.m. – 2:00 p.m.	Platinum 4
PELS TC4 Vehicle and Transportation Systems Technical Committee	1:00 p.m. – 2:30 p.m.	Platinum 7
eGrid Steering Committee	1:30 p.m. – 2:25 p.m.	Platinum 2
PELS Standards Committee & ITRW	2:00 p.m. – 4:00 p.m.	Platinum 3

TUESDAY, MARCH 19 *(Continued)*	Time	Location
PEDG Steering Committee	2:30 p.m. – 3:55 p.m.	Platinum 2
PELS TC6 - High Performance and Emerging Technologies	2:30 p.m. – 4:00 p.m.	Platinum 8
PELS Bylaws and Constitution	3:30 p.m. – 4:30 p.m.	Platinum 4
PELS Industry Advisory Board	4:00 p.m. – 4:55 p.m.	Platinum 2
PELS TC2 Power Conversion Systems and Components	4:00 p.m. – 5:30 p.m.	Platinum 7
PELS Global Relations Committee	4:30 p.m. – 5:30 p.m.	Platinum 3
Power Electronics Magazine Editorial Board	5:00 p.m. – 6:30 p.m.	Platinum 2
PELS TC5 - Sustainable Energy Technical Committee	5:30 p.m. – 7:00 p.m.	Platinum 4
IEEE IAS/PELS Young Professional Reception *(Separate Registration Required)*	7:00 p.m. – 9:00 p.m.	Offsite
WEDNESDAY, MARCH 20		
PELS Women In Engineering (WIE) Breakfast	8:00 a.m. – 9:00 a.m.	Platinum 2&3
PELS TC3 Motor Drives & Actuators	8:30 a.m. – 10:00: a.m.	Platinum 4
Electronics Transformers Technical Committee (ETTC)	9:00 a.m. – 11:55 a.m.	Platinum 7
PELS Products Committee	9:30 a.m. – 11:30 a.m.	Platinum 2&3
PELS Cyber-Physical Security Meeting	10:30 a.m. – 12:00 p.m.	Platinum 4
PELS New AdCom Member Orientation	12:00 p.m. – 1:25 p.m.	Platinum 7
IEEE Transactions on Power Electronics Editorial Board	12:00 p.m. – 2:30 p.m.	Platinum 2&3
PELS and CPSS Exec Team	1:30 p.m. – 2:25 p.m.	Platinum 4
PELS Technical Operations Committee	2:30 p.m. – 4:30 p.m.	Platinum 7
THURSDAY, MARCH 21		
PELS Conference Committee Breakfast	8:00 a.m. – 8:55 a.m.	Platinum 3
PELS Conferences Committee	9:00 a.m. – 11:30 a.m.	Elite Ballroom
PELS Administrative Committee	2:00 p.m. – 5:30 p.m.	Elite Ballroom
PELS Administrative Committee Dinner *(Members Only)*	6:30 p.m. – 9:00 p.m.	Offsite
FRIDAY, MARCH 22		
PELS AdCom Breakfast *(Companions Welcome)*	7:00 a.m. – 7:55 a.m.	Elite Ballroom
PELS Administrative Committee	8:00 a.m. – 11:30 a.m.	Elite Ballroom

PROFESSIONAL EDUCATION SEMINARS

APEC strives to offer seminars with a practical mix of theory and application for the professional working in power electronics. APEC 2019 features 18 professional education seminars with a broad range of topics.

SESSION 1

9:30 a.m.–1:00 p.m.

S01: Design and Integration of WBG Solid State Circuit Protection

ROOM 210AB

Track: Components

Douglas Hopkins; Utkarsh Mehrotra; Bahji Ballard,
NC State University, NC, USA

This seminar targets Solid State circuit protection for medium voltage or high-power systems. Advances in power electronics driven by the development of WBG devices and the proliferation of wind and solar power is shifting the way we consume and distribute electric energy. Conventional circuit protection is simply too slow to deal with the ramp rates that result from the overall reduction in inductive loads on a given system. Solid State circuit breakers offer a solution to this problem though it comes with its own challenges and limitations.

This seminar gives an in-depth exploration of solid-state circuit breaker technology and introduces a design philosophy that guides the intermediate practitioner in addressing each of these challenges. Special attention is given to the problem of energy absorption during a short circuit event, both electrical and thermal. A design example of a 6.5 kV, 100A solid state circuit breaker is provided.

The attendee is shown, in detail, the justification for circuit breaker ratings and the motivation for the integration of protection features into power electronic circuit design. Brief tutorials in heat transfer and mechanics provide an understanding behind maximum operating limits and reliability drivers, and procedures to iterate the electrical-physical design.

9:30 a.m.–1:00 p.m.

S02: Advances in Modeling & Simulation for Magnetics & Control

ROOM 303AB

Track: Control

Ray Ridley, *Ridley Engineering, US, United States*

This seminar will present the latest simulation tools for modeling complex phenomena in magnetic circuit elements and control. The results of Dowell's equations and Steinmetz equations are presented as simple circuit models. Time domain simulation of these models provide details of losses that were previously only possible with very complex analysis that was beyond the reach of most designers. Correct simulated winding losses are produced regardless of current waveshapes.

New circuit models will also be presented for core loss of converters. These models allow core loss to be calculated real-time during a simulation, eliminating the need to post-calculate flux excursion values and flux waveforms.

All of the results are easily implemented in Spice simulations providing unprecedented accuracy for magnetics loss.

We will also present the latest advances in control analysis of converters. We will show how it is now possible to predict control transfer functions for control implementations that were previously too complex to analyze.

9:30 a.m.–1:00 p.m.

S03 : Embedding Passive &Active Components PCB Design, Fabrication Methodologies &Assembly Process Strategy

ROOM 303CD

Track: Design

Vernon Solberg, *Solberg Technical Consulting*

Both uncased active and passive component elements are candidates for embedding but the process of selecting these components must be made early in the design process. Developers have realized that in addition to passive components, embedding one or more active die elements on an inner layer of the circuit in close proximity to prepackaged semiconductor(s) mounted on the uter surface, electrical interface between components can be minimized, considerably improving functional performance. This closer coupling of key passive and active semiconductor elements will:

- Significantly reduce inductance
- Contribute to increasing signal speed
- Lower overall power consumption

Some components are easy candidates for integrating into the substrate while others may involve more complex processes and will be difficult to rationalize. And although a majority of the discrete passive and active devices may remain mounted on the outer

surfaces of the circuit board, embedding a majority of the resistor functions and one or more silicon-based semiconductor elements within the inner layers of the structure can enable greater utilization of the circuit boards outer surfaces. This half-day course furnishes a comprehensive introduction to IPC-7092, Design and Assembly Process Implementation for Embedded Components.

9:30 a.m.–1:00 p.m.

S04: Design Issues for High Power and High Performance SiC Converters

ROOM 304AB

Track: High Power Applications

Jiangbiao He; Juan Sabate; Michael Schutten; Yash Veer Singh; Zheyu Zhang, *GE Global Research Center, USA*

This intermediate level seminar presents high-power silicon carbide (SiC) power converter opportunities and challenges. Multiple high-performance applications are provided: electric propulsion drives, multilevel inverters, and energy storage systems. Attendees with fundamental power converter knowledge will learn how to design SiC power systems and the associated challenges. SiC has multiple advantages over its silicon (Si) counterpart including lower losses, higher switching frequencies, higher voltage operation, and improved thermal performance. However, faster SiC switching transitions lead to electromagnetic emission problems, susceptibility difficulties, and insulation degradation.

This seminar introduces attendees to efficient and compact two-level and multilevel megawatt converters and propulsion drives enabled by SiC. The seminar provides detailed design approaches for inverter design and construction, power-stage design challenges and solutions, novel and cost-effective gate drive circuits, multi-stage power quality filter, switching and conduction loss calculations, and thermal management. The presentation includes detailed description for three power electronic systems using SiC. Experimental results verify the design performance. SiC power converters have undesirably large high frequency harmonics, creating electromagnetic interference (EMI) problems. Approaches for high attenuation filter development, and proper system construction techniques are derived and experimentally verified.

9:30 a.m.–1:00 p.m.

S05: Hybrid and Resonant Switched-Capacitor Converters: New Circuit Topologies and Control Techniques for High Power Density Designs

ROOM 210CD

Track: Topology and Circuits

Robert Plawa, *U.C. Berkeley, USA*

This tutorial will cover the topic of hybrid and resonant switched-capacitor (SC) power converters. This class of converters has received increased atenton lately, owing to superior power density and efciency compared to conventonal approaches. Startng with a detailed overview and analysis of conventonal SC power converters, the limitatons and design constraints of SC converters will be highlighted. Moreover, derivaton of the fast and slow switching limits, along with SC circuit analysis tools such as charge transfer analysis will be covered. The concept of sof charging in SC converters through current source behavior and resonant operaton will be introduced, along with analytcal techniques for determining which SC converter topologies are amenable to this hybrid mode of operaton. Circuit and control techniques for extending the family of sof-charging SC converters will be demonstrated, along with various methods for evaluatng hybrid SC converter topologies. Figures of merit for di erent circuit topologies will be discussed to evaluate potental for high power density and efciency, along with recent examples of high performance hardware prototypes. Finally, practcal challenges such as gate driving, startup, and capacitor voltage balancing will be discussed, along with recent proposed techniques to mitgate such difcultes.

9:30 a.m.–1:00 p.m.

S06: WBG Device Characterization for Converter Design: Challenges and Solutions

ROOM 213CD

Track: Wide Bandgap

Fred Wang; Zheyu Zhang; Edward Jones, *EPC, CA, USA; GE Global Research, NY, USA; University of Tennessee at Knoxville, TN, USA [respectively]*

At the heart of modern power electronics converters are power semiconductor devices. The emergence of wide bandgap (WBG) semiconductors, including silicon carbide (SiC) and gallium nitride (GaN), promises power electronics converters with higher efficiency, smaller size, lighter weight, and lower cost than converters using the established silicon-based devices. However, WBG devices pose new challenges for converter design and require more careful characterization, in particular due to their fast switching speed and smaller die size. This seminar presents comprehensive methods with examples for the characterization of GaN and SiC power devices, including static, dynamic, and thermal characteristics. The seminar will have a strong focus on application-oriented device characterization, for the purposes of optimizing a WBG-based converter design. Topics will include challenges particular to GaN and SiC-based converter design, such as cross-talk, dynamic on-resistance, and parasiticeffects of

ractical loads and different topologies. The presentation will conclude by demonstrating how a detailed device characterization can be applied to improve a converter design. The intended audience includes university professors and graduate students, practicing industry engineers, and other researchers working on WBG-based power electronics. Content will range from intermediate to advanced, and requires only a basic knowledge of device characteristics and converter design.

SESSION 2

2:30 p.m.–6:00 p.m.

S07: Magnetic Design Fundamentals – What They Didn't Tell You

ROOM 303AB

Track: Components

George Slama, *Wurth Electronics, United States*

There are lots of experts showing you how to do high frequency magnetics design - from using only one formula to pages and pages of equations. Magnetics design is about turning some electrical requirement into a physical object that obeys the laws of electromagnetics. It also has to be manufacturable, meet changing safety standards, be reliable and low cost. Why does that transformer have a funny looking coil former? Why is that one wrapped with tape like a Christmas present? I don't recall any mention of that. What else do you need to know in order to design, make or just specific a 'magnetic' component? This seminar covers a broad range of topics related to designing, specifying and building real magnetic components, not just samples in the lab. Learn the details that others left out.

Get background on the various types of core materials – their characteristics, strengths and weakness, explains all the terms, how to read datasheets and their best application. Learn about wire, winding, windings and the insulation used between them. Understand which international safety standards apply and how to implement them. Finishes with design for manufacturing - why it's important and what's involved.

2:30 p.m.–6:00 p.m.

S08: A Comprehensive Introduction to Digital Control for Power Electronic Converters

ROOM 304AB

Track: Control

Joel Steeins; Alex Dumais, *Microchip Technology, United States*

The purpose of this presentation is to provide an in-depth introduction to designing and implementing fully digital controllers. The presenters will cover a broad selection of topics in modeling, control design, and practical implementation. The presentation will start by reviewing topics in linear systems theory, discuss mapping from continuous-time to discretetime, control objectives, limitations on performance, shown how to represent discrete time controllers using fixed point math, show representations of fixed point controllers (direct form I, direct form II, and state space as single section or cascaded section controllers), computational errors due to finite precision will be discussed, and a number of software implementations will be shown with hardware results.

2:30 p.m.–6:00 p.m.

S09: Thermal Design of Power Electronics

ROOM 303CD

Track: Design

Lauren Boteler, *U.S. Army Research Laboratory, United States*

There is a continual pull in the power electronics industry for smaller modules with increased power to improve power conversion for electric vehicle drive trains and other applications. This increased power density leads to thermal and packaging challenges that must be understood and addressed. As modules become increasingly integrated and complex, it is important for everyone in the design chain to understand the thermal challenges. This entry level tutorial will address basic thermal management issues as it relates to a power electronics module. The course will begin with a fundamental understanding of the three mechanisms of heat transfer (conduction, convection, and radiation). Next, it will cover how to perform thermal resistance network calculations to understand the thermal impact of material selection, heat sink options, and geometries. As part of this analysis, various thermal terms will be defined including thermal resistance, heat transfer coefficients, thermal conductivity, fluid pressure drop, heat flux, and thermal spreading. Additional topics will include the pros and cons of typical thermal management solutions, temperature measurement options, how to read the thermal properties on a datasheet, and understanding simulation results. This tutorial will provide the background necessary to perform back-of-the-envelope thermal calculations, understand the available thermal management solutions, and appreciate the thermal management challenges facing today's power electronics industry.

2:30 p.m.–6:00 p.m.

S10 : High Power and Medium Voltage Applications of Wide Bandgap Power Devices

ROOM 210AB

Track: High Power Applications

Jin Wang[2]; Mark Scott[1], *[1]Miami University, United States; [2]The Ohio State University, United States*

The tutorial focuses on high power applications of gallium nitride (GaN) and silicon carbide (SiC) devices. It starts with a brief introduction to current development status of GaN and SiC devices. Then, common issues that are faced by both GaN and SiC devices including gate drive designs, high dv/dt caused reflective waves, short circuit capabilities, electromagnetic interference, etc, are discussed in detail. A 10 kW GaN based three-phase inverter and a 1.7 kV SiC based 7-kV 1-MVA SiC modular multilevel converter (MMC) are the case studies presented during this lecture. For future higher voltage and higher power applications, the tutorial discusses design challenges with medium voltage (3.3 kV to 15 kV) SiC devices. Insulation requirements, auxiliary power supply designs, fast short circuit protection, and partial discharge related design considerations are covered in detail. Multiple examples of 3.3 kV, 4.5 kV and 10 kV based circuit building blocks are included as case study examples.

2:30 p.m.–6:00 p.m.

S11: Modular High Frequency High Voltage Power Supply: Architectures, Unified Modeling Methodologies and Output Voltage Sharing Technologies

ROOM 210CD

Track: Topology and Circuits

Saijun Mao[2]; Braham Ferreira[1], *[1]Delft University of Technology, Netherlands; [2]Leadrive Technology (Shanghai) Co., Ltd, China*

This tutorial focuses on the modular high frequency high voltage power supply technologies. The modular high voltage power supply architecture with a distributed inverter, high voltage transformer and multiplier will reduce the electrical and insulation, as well as thermal stress for the key components compared with convention centralized high voltage power supply. The modular architecture helps to achieve high power density and offer the scalability of output voltage and power for high voltage power supply system. The tutorial starts with the introduction of high frequency high voltage power supply including the basics, development history, the state-of-the-art technologies and future technology trends. The architecture derivation, classifications and evaluation of high voltage power supply will be introduced firstly. Secondly, the generic steady-state circuit modeling approach for different high voltage generation architectures will be presented. The generic model can be applied to the high voltage power supply with different architectures, different voltage multiplier topologies, stage and polarities number to simplify the analysis. Thirdly, the analysis of the output-voltage unbalance mechanism for the modular high voltage power supply is performed considering the parameter variation of the HV transformer including the magnetizing inductance, leakage inductance and secondary winding capacitance. The output-voltage sharing mechanism of proposed coupledinductor based modular high voltage power supply with the primary-parallel-secondary-series (PPSS) configuration is given. Finally, the technology demonstrator and design examples of the modular high voltage power supply will be provided to validate the advantage of modular architectures and output sharing with the coupled-inductor solution. The audience will be the entry level and intermediate university students and engineers in industry who are interested in high voltage and pulsed power supply technologies.

2:30 p.m.–6:00 p.m.

S12: Ten Most-Commonly Asked Questions on Migrating from Si to SiC MOSFET-Based Converter Designs

ROOM 213CD

Track: Wide Bandgap

David Levett; Kwokwai Ma, *Infineon, China; Infineon, United States*

For APEC 2019 professional education seminar, we decided to turn the traditional process around and rather than us decide the topics, we decided to ask our global customer base of design and our field application engineers what questions they would want answered in a technical forum. This seminar is the result taking a world-wide survey asking the simple question "what are the questions you have related to using SiC MOSFETs"? We have taken the results and produced a list of the top 10 most common questions and will, during the seminar, attempt to provide detailed answers. This includes topics such as what about long term reliability, how to protect devices, can they be paralleled and how to implement synchronous rectification? As usual the emphasis will be on practical application and examples from real world applications and measurements.

PROFESSIONAL EDUCATION SEMINARS

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SESSION 3

8:30 a.m.–12:00 p.m.

S13: Latest Trends in Magnetic Technology for High Efficiency and High Power Density

ROOM 303AB

Track: Components

Ionel Jitaru, *Rompower, United States*

There was a significant progress in semiconductor technology in the last twenty years which pushed the power conversion efficiency from low to midle 80% to low to midle 90% over the last twenty years. Durring the same time period the progeres in magnetic technology was practically negligeable. We all were wating for a „mirracle" new core material whcih will allow us to make the next jump. Though not much publisized, in magnetic tehcnology there were many new ideas but these ideas did capture just fragments of the market due the proprietaty nature of these new technology. Some of these new ideas are in public domain these days but many of the engineers were not expose to them.

The goal of the seminar is to bring some light into the modern magentic technologies and to teach the engineers how to rethink the magentic design for high efficiency and high power desnity.

The seminar will present a comprehensive overview of the modern magnetic technologies presently used in power conversion and new trends in magnetics aimed to address the new demands in power conversion. In the quest for higher power densities and higher efficiency magnetic technologies were forced to adapt and then new magnetic structures were developed.

The seminar will start by presenting several key characteristics of magnetic transformers such as leakage inductance, stray inductance, inter-winding and intra-winding capacitances and their impact in power conversion performance. Methods of measuring and controlling these parasitic elements are also presented. The seminar will present experimental results and methods of measuring the key magnetic parameters for application ranging from low power tranformers for adapters to several KW tranformers for server and telecom applications.

The seminar will also show some present and future trends in magnetics for higher frequency operation. A chapter will be dedicated to the new trends in magnetic technology for very high efficiency applications. These new magnetic technologies are compatible with the latest technologies in power conversion aimed at very high efficiency and very high power density. The seminar will address different applications such as 30W-65W AC-DC power adapters to multiple KW DC-DC converters and Power Factor Correction modules with very high efficiency. The presentation will be highlighted with design guidance, design example and experimental results.

8:30 a.m.–12:00 p.m.

S14: Systematic Approach to Control of Electrical Drives and 3-Phase Converters

ROOM 303CD

Track: Control

Tony O'Gorman[1]; Vladimir Blasko[2], *[1]PESC Inc, United States; [2]UTRC, United States*

This intermediate level tutorial is intended for the practicing engineer who has some familiarity with motor control or power factor correction or grid tied 3 phase converter but wants to apply more sophisticated control techniques. The derivation of DQ vectors will be provided from first principles so a common baseline can be established. Then, the application of the DQ technique will be applied to three phase power factor and motor applications. Subsequently, current loops will be closed using standard techniques which will highlight some of the issues with these standard approaches.

In many cases where three phase current or voltage loops are closed, periodic disturbances need to be eliminated. One way to accomplish this is using the internal model principle and the application of adaptive noise cancelling or harmonic regulators. Theoretical analysis and simulation will be used to demonstrate the effectiveness of these techniques. Methodology for tuning of voltage, speed and current regulators for electrical drives and grid tied converters will be developed. Further, the impact of PWM delays, controller processing time, filtering etc will be shown using analysis and simulation. This impact will be augmented with experimental results and compared to the simulated predictions.

8:30 a.m.–12:00 p.m.

S15: Fundamentals of Design for Reliability in Power Electronics

ROOM 304AB

Track: Design

Frede Blaabjerg; Francesco Iannuzzo; Huai Wang,

Aalborg University, Denmark

The aim of this tutorial is to provide fundamentals of design for reliability of power electronic systems, together with the recent findings and paradigm shifts in this research area. It will cover the reliability requirements in different industry sectors, reliability and lifetime of semiconductor modules and capacitors used in power electronic converters, testing of power components, and the specific designfor-reliability procedure for power electronic systems. A hands-on example of reliability stimation, as long as some case studies on the design-for-reliability paradigm are also presented. Finally, cuttingedge mission-profile based lifetime estimation as well as condition monitoring principles in power converters will conclude the tutorial. The approaches presented are also the common interest for the companies involved in the Center of Reliable Power Electronics (CORPE) at Aalborg University (http://www.corpe.et.aau.dk/). The tutorial will also present the views of the instructors on future research opportunities in the area of reliability of power electronics. Researchers and engineers who seek the basic knowledge for entering in this field, ranging from component level to system level, from physic of failure to statistical analysis are the main target audience of the seminar. Prerequisites are: circuit theory and power electronics basics.

8:30 a.m.–12:00 p.m.

S16: Electric Powertrain: Energy Systems, Power Electronics and Drives for Hybrid, Electric, and Fuel Cell Vehicles

ROOM 213CD

Track: High Power Applications

John Hayes[1]; Abas Goodarzi[2], *[1]UCC, Ireland; [2]US Hybrid, United States*

The new book Electric Powertrain: Energy Systems, Power Electronics and Drives for Hybrid, Electric and Fuel Cell Vehicles is a structured holistic textbook for the teaching of the undamental theories and applications of energy sources, power electronics, and electric machines and drives to engineering students. This four-part practical guide also acts as an industry reference. In this introductory tutorial, the authors present a three-part seminar covering Electric Vehicles & Energy Sources, Power Electronics, and Electrical Machines. The first half of the tutorial is a lively overview of electromobility with its strong California roots. Battery electric vehicles, fuel cell electric vehicles, and conventional and hybrid electrical vehicles are described, contrasted and compared for vehicle propulsion. As the vehicle is now understood, the machines and related power electronics are next discussed. The second part of the tutorial provides an overview of the traction machines used in propulsion, with a focus on the induction and IPM ac machines. The third part of the tutorial presents an integrated holistic overview of the power electronics, and discusses the propulsion, charging, accessory, and auxiliary power converters. Isolated and nonisolated dc-dc converters and traction inverters are all discussed, with an additional special focus on battery charging.

8:30 a.m.–12:00 p.m.

S17: Simulation and Analysis Applied to the Design of Buck Topologies

ROOM 210AB

Track: Topology and Circuits

Christophe Basso, *ON Semiconductor, France*

This seminar continues the detailed exploration of switching converters using simulation, analysis and practical experiments. The buck converter is selected as a topology vehicle to explore different voltage- and current-mode control schemes (fixed frequency, quasi-square wave resonance, COT and FOT), highlighting pros and cons of each solution. Small-signal models are then presented with a discussion on performance and implementation of past and more modern models. The four transfer functions of the CCM buck operated in peak-current-mode-control are derived using fast analytical circuits techniques. The seminar ends with the presentation of measurements carried on prototypes and nicely bridges theory with practical aspects.

Using mathematical analysis and different tools such as SPICE and Mathcad®, the author maintains a permanent link between theory and practical reality. Balancing analyticalaspects and real-case examples, the seminar targets an audience with an intermediate background in the presented subject.

8:30 a.m.–12:00 p.m.

S18: What Makes SiC Better and How Do I Change My System to Benefit

ROOM 210CD

Track: Wide Bandgap

Xuning Zhang, *Littelfuse Inc., United States*

Silicon Carbide (SiC) devices improve the power density of various converters by shrinking the size of passive components and improving the power conversion efficiency. This seminar presents an in-depth summary of SiC devices and its applications to help converter designers at different levels to understand the benefits and challenges brought by using SiC devices and provide design guidelines for converter designers to extract the maximum benefit from using SiC devices. The presentation will begin with an introduction of SiC technology status. A summary of internal device structure and principle of operation will be discussed to understand the potential benefits from SiC technology. Detailed static and dynamic characteristics, thermal performance and device ruggedness will be discussed with related datasheet parameters to verify the superior performance of SiC devices over Si. II. Optimal implementation of SiC MOSFET will be discussed in detail from the aspects of driving voltage selection, driving loss and driving power supply structures, protection design power loop optimizations. This will provide design guidelines for converter designers to implement SiC devices appropriately to ensure its maximum benefits. Design examples in real applications such as solar inverters and EV chargers will be presented with real hardware and test results to verify the benefit of using SiC device in system size/ weight/ cost reduction compared with Sidevices with different focus of performance improvements for different power converter designs.

PLENARY SESSION

The APEC 2019 Plenary Session is designed to cover the history of power, the current needs in energy efficiency and the future possibilities. The plenary is made up of several presentations from respected industry leaders. Each presentation is 30-minutes in length and allows for interactive Q&A at the end of each presentation.

Presentation #1
The Future of Power Electronics in Robotics Applications

1:30 p.m. – 2:00 p.m.

SPEAKER:

Peter Wawer

Division President, Industrial Power Control, Infineon Technologies

By harnessing the latest advances in power electronics, control, sensors, and communication, robotics are accelerating efficiency gains in our industrialized economy. From smart robots to collaborative robots, and from virtual fences to energy flexibilization, robotics disciplines play a central role in the Industry 4.0 deployment. Yet many new exciting uses for robotics have to be realized. What is the future of power electronics in robotics applications? From control algorithms to smart motor drives using latest power semiconductor technologies, power electronics will play a key role in reaching the next level era of making our world greener and our lives safer.

Presentation #2
Overview of University Research Programs in Power Electronics

2:00 p.m. – 2:30 p.m.

SPEAKER:

Robert V. White

Chief Engineer, Embedded Power Labs (representing PSMA)

Every two years, PSMA publishes an updated Power Technology Roadmap (PTR). The purpose of the PSMA Power Technology Roadmap (PTR) is to present a look at power technology and trends over the next five years. This year, to get a different and longer-term look ahead, the PSMA selected universities and research institutions that are leaders in various areas of power electronics research. These universities and institutions were invited to share information about the research that their institution would be pursuing in upcoming years, as well as provide some metrics about their research program. The results of this survey will be presented. Areas of common interest will be highlighted along with unique activity. Observations will also be shared on potential gaps in coverage.

Presentation #3
Flywheel Energy Storage: A Utility Scale Energy Solution for the 21st Century

2:30 p.m. – 3:00 p.m.

SPEAKER:

Seth Sanders

Chief Scientist and Co-Founder, Amber Kinetics

Energy storage is now emerging as an essential electric utility resource to effectively enable higher penetration levels of variable renewable generation resources. In California, in response to RPS mandates for increased renewable penetration, Assembly Bill 2514, in conjunction with resulting California Public Utilities Commission rulings, has called for 1.3 GW of flexible energy storage to be incorporated into the energy mix by California utilities by 2024. Similar actions have been enacted, or are in process, in other U.S. states, and worldwide. The talk will review the energy storage landscape, in terms of opportunity, established and emerging storage technologies, and commercial progress. The talk will also focus on the speaker's interests in advancing flywheel energy storage to meet utility scale challenges. In short, a flywheel functions as a battery, with kinetic energy storage replacing conventional electrochemical processes. Based on numerous implementations and products released during the past 20-30 years, there has been a general belief in the power systems community that flywheels are only suited to short term applications, for example in frequency regulation, grid stability enhancement, voltage support, and in UPS and transit system applications. This is not the case, and the talk will outline how flywheels can be economically designed to meet multi-hour energy shifting applications, that are essential for provision of capacity, and extended integration of variable renewable generation. Some details on product and project development at grid scale energy storage start-up Amber Kinetics will be discussed.

Break

3:00 p.m. – 3:30 p.m.

Presentation #4
Power Electronics; Enabling Zero Emission Powertrains and Fuel Cell Engines

3:30 p.m. – 4:00 p.m.

SPEAKER:

Abas Goodarzi

President and Chief Executive Officer, US Hybrid Corporation

This presentation gives a review of fuel cell engines enabling zero emission transportation. Electric traction is recognized as the future of mobility and energy conservation with battery electric, fuel cell electric and hybrid combustion engines as competing platforms. The combination of advances in power conversion systems with rapid advances in vehicle control and autonomous driving, e.g. predictive GPS based route optimization, has enabled commercially-viable vehicles.

A Fuel Cell is a combustion-less/static engine that generates electric power directly by extracting the electrons from hydrogen to power the future transportation. Thus, power electronics are directly involved in both power generation and propulsion of the vehicles. Power electronics utilizing SiC devices are integrated with the fuel cell engine to provide the highest power density and more than triple the overall efficiency (fuel in, electric power out) with zero tail pipe emission enabling global GHG reduction and Carbon-free economy. Power Electronics become the workhorse enabling future mobility by also enabling the balance of plant system for the fuel cell engines including air compressor, thermal management and fuel processing units.

Presentation #5
Improving Healthcare through Power Electronics: Opportunities in Powering Medical Devices

4:00 p.m. – 4:30 p.m.

SPEAKER:

Rikky Muller

Co-Founder, Cortera Neurotechnologies

Smart and connected medical implants are the next frontier in the Internet of Things (IoT) and are set to revolutionize healthcare. Advancing our ability to interface technology with biological environments will enable patients to be monitored and receive treatment at home, and in the long term, have chronically implanted electronic devices seamlessly integrate with their everyday lives. The power source and the design of the power electronics in medical devices have significant impact in their form factor, function, usability and safety. This talk explores various powering modalities of medical devices, including emerging techniques for remote powering of millimeter- and micron-scale implantable devices utilizing electromagnetic power or ultrasound. Such devices will enable continuous monitoring of nervous system functions and will deliver bioelectronic medicine to treat neurological diseases, inflammatory diseases, respiratory diseases and more. Power designers have the opportunity to play a significant role in enabling these new devices by expanding their functionality, efficiency, safety and longevity.

Presentation #6
Power Electronics for the Space Exploration Hype

4:30 p.m. – 5:00 p.m.

SPEAKER:

Fernando Gómez-Carpintero

Head of Power Engineering, Airbus Spacecraft Electronics

The space business shows a convergence of all factors and signs toward a major disruption. The market is moving towards a much more dynamic environment with new players, strong private investors and new business models, which answer the demand for a hyper connected world and for data-driven economies. These impose in the industry a tremendous pressure for shorter time to market and significant price reduction while increasing the performances of the electronics. On top of that, there is a new hype for space exploration with a clear need for higher power and higher efficiencies to drive the electrical propulsion systems. The answer from Airbus Space Electronics includes the use of new technologies like GaN, the implementation of digital control for smart power management, the use of COTs (Commercial Off the Shelf) EEE components and the digitalization & automation of the development process..

INDUSTRY SESSIONS

At APEC 2019, the Industry Sessions track continues to expand. This track runs in parallel with the traditional Technical Sessions Track Speakers are invited to make a presentation only, without submitting a formal manuscript for the APEC Proceedings. This allows APEC to present information on current topics in power electronics from sources that would not otherwise be present at an industry conference. While many of these sessions are technical in nature, some also target business-oriented people such as purchasing agents, electronic system designers, regulatory engineers, and other people who support the power electronics industry. Presentations will be available through the APEC mobile app.

8:30 a.m. – 11:55 a.m.

IS01: High Frequency Magnetics; New Magnetic Materials

ROOM 210BC

CHAIR:

Ed Herbert, *PSMA*

8:30 a.m. – 8:55 a.m.

IS01.1 **Materials Paradigm as Applied to New and Evolving Power Magnetic Materials**
Michael McHenry[1], P. R. Ohodnicki[3], A. Leary[2]
[1]Carnegie Mellon University, United States; [2]NASA Glenn Research Center, United States; [3]National Energy Technology Laboratory, United States

8:55 a.m. – 9:20 a.m.

IS01.2 **Strain Annealed Metal Amorphous Nanocomposite Soft Magnetic Materials: Manufacturing, Applications, Optimization, and Data Sheets**
Seungryul Moon[2], Kevin Byerly[1], Paul Ohodnicki[1], M.E. McHenry[1], Satoru Simizu[1], Alex Leary[1], Vladimir Keylin[1], Ronald Noebe[1], Randy Bowman[1], Richard B. Beddingfield[1], Subhashish Bhattacharya[1]
[1]National Energy Technology, United States; [2]National Energy Technology Laboratories, United States

9:20 a.m. – 9:45 a.m.

IS01.3 **High Bs Ferrite Material for High Power Applications**
Jun Sun
Bs&T Frankfurt am Main GmbH, Germany

9:45 a.m. – 10:10 a.m.

IS01.4 **Design Considerations for High Frequency Magnetic Materials**
John Lynch, Michael Arasim
Fair-Rite Products Corp, United States

10:10 a.m. – 10:40 a.m.

Break

10:40 a.m. – 11:05 a.m.

IS01.5 **Soft Magnetic Metal-Flake Composite Material Suitable for High Frequency Power Modules**
Ken'Ichi Chata'Ni
TOKIN Corporation, a KEMET Company, Japan

11:05 a.m. – 11:30 a.m.

IS01.6 **New and Modified Alloy Powder Core Materials**
Mark Swihart
Magnetics, United States

11:30 a.m. – 11:55 a.m.

IS01.7 **Materials Magic – Nanocrystalline, Amorphous and Powdered Amorphous Cores**
Mark Rine
Hitachi Metals America, Ltd., United States

8:30 a.m. – 11:55 a.m.

IS02: Data Center

ROOM 209AB

Harry Soin, *Artesyn Embedded Technologies*

Mingchun Xu, *Facebook*

8:30 a.m. – 8:55 a.m.

IS02.1 **5 Common Mistakes in Point-of-Load DC-DC Converters and How to Avoid Them**
Anthony Fagnani, Pradeep Shenoy
Texas Instruments, United States

8:55 a.m. – 9:20 a.m.

IS02.2 **3 kW Full Bridge LLC Resonant Digital Converter**
Mario Di Guardo
STMicroelectronics, Italy

9:20 a.m. – 9:45 a.m.

IS02.3 **Optimising Light Load Efficiency in TM Boost PFCs**
Billy Long, Joseph Leisten
Texas Instruments, Ireland

9:45 a.m. – 10:10 a.m.

IS02.4 **Solid State Inrush Current Limitation**
Yannick Hague, Thierry Castagnet
STMicroelectronics, France

10:10 a.m. – 10:40 a.m.

Break

10:40 a.m. – 11:05 a.m.

IS02.5 **ZVS Switched Capacitor (ZSC) Converter for Future Data Center Applications**
Matt Hunter[1], Min Chen[1], Christian Rainer[2], Yong Zhou[1], Rakesh Renganathan[1]
[1]Infineon Technologies Americas Corp., United States; [2]Infineon Technologies Austria AG, Austria

11:05 a.m. – 11:30 a.m.

IS02.6 **Evaluation of GaN based Multi-Level Converters**
Suvankar Biswas
Efficient Power Conversion Corporation, United States

11:30 a.m. – 11:55 a.m.

IS02.7 **Improving Software Quality in Digital Power Control**
Hamish Laird
ELMG Digital Power, United States

8:30 a.m. – 11:55 a.m.

IS03: Vehicle Electrification

ROOM 210A

CHAIRS:

Dennis Stephens, *Continental Automotive*

Weimin Zhang, *ST Motors Inc.*

8:30 a.m. – 8:55 a.m.

IS03.1 **Efficiency and Robustness for SiC MOSFETs: Key Role, Trade-Off and Technology Improvement for Traction Inverter Solutions**
Mario Pulvirenti, Angelo Giuseppe Sciacca, Gionatan Montoro, Massimo Nania
STMicroelectronics, Italy

8:55 a.m. – 9:20 a.m.

IS03.2 **Lifetime and Reliability Enhancement of a New IGBT Module for Traction Applications**
Kevork Haddad
SEMIKRON, Inc, United States

9:20 a.m. – 9:45 a.m.

IS03.3 **SiC MOSFET Based High-Efficiency Bi-Directional On-Board Charger for EVs**
Jianwen Shao, Binod Agrawal, Frank Wei
Wolfspeed, United States; Wolfspeed, China; Wolfspeed, India

9:45 a.m. – 10:10 a.m.

IS03.4 **ICs for the Electric Powertrain**
Wouter Leten, Andrew Wilson
Melexis, Belgium; Melexis, United States

10:10 a.m. – 10:40 a.m.

Break

10:40 a.m. – 11:05 a.m.

IS03.5 **Advantages of 3.3kV SiC-MOSFET Modules in Traction Applications**
Mark Steiner[2], Eric Motto[2], Kenji Hatori[1]
[1]Mitsubishi Electric, Japan; [2]Mitsubishi Electric US, United States

11:05 a.m. – 11:30 a.m.

IS03.6 **Silicon Carbide Enabling Car Electrification**
Vittorio Giuffrida, Simone Buonomo, Anselmo Gianluca Liberti
STMicroelectronics, Italy

11:30 a.m. – 11:55 a.m.

IS03.7 **The Value of GaN HEMTs in 800V and Above Applications**
Juncheng Lu[1], Yunwei Li[2], Zhongyi Quan[2]
[1]GaN Systems, Canada; [2]University of Alberta, Canada

8:30 a.m. – 11:55 a.m.

IS04: Getting Up To Speed on Switching: Wide Band Gap & Other High Performance Components

ROOM 210D

CHAIRS:

Stephanie Watts Butler, *Texas Instruments Inc.*

Jaume Roig, *ON Semiconductor*

8:30 a.m. – 8:55 a.m.

IS04.1 **Magnetics Study Enables New Class of High Density AC/DC Converters**
Tom Ribarich
Navitas Semiconductor, United States

8:55 a.m. – 9:20 a.m.

IS04.2 **High Performance SiC MOSFETs and Diodes Fabricated in High-Volume 6-Inch CMOS Fab**
Sujit Banerjee, Xuning Zhang, Michael Ketterer, Andreas Laschek-Enders, Levi Gant, Christophe Warin, Kevin Matocha, Gin Sheh
Littelfuse Inc., United States; Littelfuse Inc., Germany

9:20 a.m. – 9:45 a.m.

IS04.3 **GaN Integrated Circuits for Highest Performance Power Supplies**
Thierry Bouchet
GaNWISE, France

9:45 a.m. – 10:10 a.m.

IS04.4 **GaN-on-Silicon Intelligent Power Switch Solutions**
Eric Moreau
Exagan, France

10:10 a.m. – 10:40 a.m.

Break

10:40 a.m. – 11:05 a.m.

IS04.5 **Avalanche and Short-circuit Robustness of High Voltage SiC DMOSFETs**
Ranbir Singh
GeneSiC, United States

11:05 a.m. – 11:30 a.m.

IS04.6 **CoolSiC Power MOSFETs: New Additions to the Portfolio**
Peter Friedrichs
Infineon Technologies, United States

11:30 a.m. – 11:55 a.m.

IS04.7 **How GaN Helps Power Supplies Achieve Extraordinary Levels of Efficiency**
Eric Persson
Infineon Technologies, United States

8:30 a.m. – 11:55 a.m.

IS05: Market Research

ROOM 213B

CHAIRS:

Ada Cheng, *Adaclock*

Carl Blake, *CBK Consulting*

8:30 a.m. – 8:55 a.m.

IS05.1 **1200V SiC MOSFETs Technology Assessment by Means of Deep Structural and Physical Analysis**
Alberto Adan, Daisuke Tanaka, Louis Burgyan, Yuji Kakizaki
LTEC Corp., Japan; LTEC Corp., United States

8:55 a.m. – 9:20 a.m.

IS05.2 **What Can Power Electronics Industry Expect from SiC & GaN?**
Ana Villamor
Yole Developpement, France

9:20 a.m. – 9:45 a.m.

IS05.3 **Power Semiconductor Trends and the Global Data Center Power Crisis**
Kevin Anderson
IHS Markit, United States

9:45 a.m. – 10:10 a.m.

IS05.4 **Every Power Electronic Company Should Be Involved in the Growing EV/HEV Industry: True or False?**
Milan Rosina, Claire Troadec
Yole Développement, France

10:10 a.m. – 10:40 a.m.

Break

10:40 a.m. – 11:05 a.m.

IS05.5 **65nm BCD for Power Management IC Sub 90nm PM Market Trends and Technology Advantages**
Erez Sarig
TowerJazz, Israel

11:05 a.m. – 11:30 a.m.

IS05.6 **Power Electronics: An Application Driven Market**
Claire Troadec, Ava Villamor, Milan Rosina, Alejandra Fuentes
Yole Developpement, France

TECHNICAL SESSIONS

APEC professionals like you participated in a rigorous peer review process and have carefully picked over 500 papers making up APEC's Technical Sessions. The review process highlights the most innovative technical solutions, and provides the highest quality possible. The technical program includes papers of broad appeal scheduled for oral presentation from Tuesday morning through Thursday afternoon. Papers with a more specialized focus are available for discussion with authors at the dialogue session on Thursday from 11:30 a.m. – 2:00 p.m. The various technical venues cover all areas of technical interest to the practicing power electronics professional. The papers are sure to give you many new design ideas that you can apply to your work immediately.

8:30 a.m. – 12:00 p.m.

T01: Hybrid DC-DC Converters

ROOM 211AB

DC-DC Converters

CHAIRS:

Yan-Fei Liu, *Queens University*

Pradeep S. Shenoy, *Texas Instruments*

8:30 a.m. – 8:50 a.m.

T01.1 **Multiphase Control for Robust and Complete Soft-Charging Operation of Dual Inductor Hybrid Converter**
Tianshi Xie[2], Ratul Das[2], Gab-Su Seo[1], Dragan Maksimović[2], Hanh-Phuc Le[2]
[1]National Renewable Energy Laboratory, United States;
[2]University of Colorado Boulder, United States

8:50 a.m. – 9:10 a.m.

T01.2 **900V SiC Based, Hybrid, Multilevel DC/DC Topology for 1500VDC PV Application**
Branislav Stevanović, Diego Serrano, Miroslav Vasić, Pedro Alou, Jesús Angel Oliver, José Antonio Cobos
Universidad Politécnica de Madrid, Spain

9:10 a.m. – 9:30 a.m.

T01.3 **A 48-to-12 V Cascaded Resonant Switched-Capacitor Converter for Data Centers with 99% Peak Efficiency and 2500 W/in3 Power Density**
Zichao Ye[1], Yutian Lei[2], Robert Pilawa-Podgurski[1]
[1]University of California, Berkeley, United States;
[2]University of Illinois at Urbana-Champaign, United States

9:30 a.m. – 9:50 a.m.

T01.4 **A Family of Transformerless Stacked Active Bridge Converters**
Jianglin Zhu, Dragan Maksimović
University of Colorado Boulder, United States

9:50 a.m. – 10:10 a.m.

T01.5 **An 80-W 94.6%-Efficient Multi-Phase Multi-Inductor Hybrid Converter**
Ratul Das[2], Gab-Su Seo[1], Dragan Maksimović[2], Hanh-Phuc Le[2]
[1]National Renewable Energy Laboratory, United States;
[2]University of Colorado Boulder, United States

10:10 a.m. – 10:40 a.m.

Break

10:40 a.m. – 11:00 a.m.

T01.6 **Zero Voltage Switching for Flying Capacitor Multilevel Converters at Nominal Conversion Ratios**
Jan Rentmeister, Jason Stauth
Dartmouth College, United States

11:00 a.m. – 11:20 a.m.

T01.7 **Two-Phase Interleaved Resonant Switched-Capacitor DC-DC Converter with Coupled Inductors and Custom LC Resonator**
Prescott McLaughlin, Phyo Kyaw, Muhammad Kiani, Charles R. Sullivan, Jason Stauth
Dartmouth College, United States

11:20 a.m. – 11:40 a.m.

T01.8 **Modulation Scheme for an Effective Increase in the Number of Levels of DC-DC Multi-Level Flying Capacitor Converters**
Michael Halamicek, Timothy McRae, Nenad Vukadinović, Aleksandar Prodić
University of Toronto, Canada

11:40 a.m. – 12:00 p.m.

T01.9 **State Space Analysis of Flying Capacitor Multilevel DC-DC Converters for Capacitor Voltage Estimation**
Ziyu Xia, Benjamin Dobbins, Jan Rentmeister, Jason Stauth
Dartmouth College, United States

8:30 a.m. – 12:00 p.m.

T02: Power Converter Modeling and Simulation

ROOM 212AB

Modeling and Simulation

CHAIRS:

Sara Ahmed, *University of Texas at San Antonio*

Jing Xu, *ABB U.S. Corporate Research Center*

8:30 a.m. – 8:50 a.m.

T02.1 **Harmonic Transfer-Function Model of Three-Phase Synchronous Reference Frame PLL Under Unbalanced Grid Conditions**
Yicheng Liao[1], Xiongfei Wang[1], Xiaolong Yue[2], Hong Gong[1]
[1]Aalborg University, Denmark; [2]Ericsson AB, Sweden

8:50 a.m. – 9:10 a.m.

T02.2 **Open-Code, Real-Time Emulation Testbed of Grid-Connected Type-3 Wind Turbine System with Hardware Validation**
Maximiliano Ferrari[3], Michael Orendorff[1], Travis Smith[2], Mark Buckner[2]
[1]NextEra Energy, United States; [2]Oak Ridge National Laboratory, United States; [3]University of Tennessee, United States

9:10 a.m. – 9:30 a.m.

T02.3 **Blackbox Parameter Varying Transfer Functions Model for Highly Nonlinear Electronic Power Converters in DC Microgrids**
Airán Francés, Rafael Asensi, Javier Uceda
Universidad Politécnica de Madrid, Spain

9:30 a.m. – 9:50 a.m.

T02.4 **Weighting Factor Design Based on Artificial Neural Network for Finite Set MPC Operated 3L-NPC Converter**
Mateja Novak, Tomislav Dragicevic, Frede Blaabjerg
Aalborg University, Denmark

9:50 a.m. – 10:10 a.m.

T02.5 **Quasi-Online Low-Frequency Impedance Monitoring Scheme for Submodule Capacitors in Modular Multilevel Converters**
Deepak Ronanki, Sheldon S Williamson
University of Ontario Institute of Technology, Canada

10:10 a.m. – 10:40 a.m.

Break

10:40 a.m. – 11:00 a.m.

T02.6 **Simplified Frequency-Domain Model of Modular Multilevel Converter**
Jianhang Zhu[1], Jiabing Hu[1], Lei Shang[1], Fei Liu[2], Zuoxia Bai[2]
[1]Huazhong University of Science and Technology, China; [2]State Grid Qinghai Electric Power Company, China

11:00 a.m. – 11:20 a.m.

T02.7 **A Modular Multilevel Converter with Self Voltage Balancing**
Yunting Liu[2], Fang Zheng Peng[1]
[1]Florida State University, United States; [2]Michigan State University, United States

11:20 a.m. – 11:40 a.m.

T02.8 **Analytical Analysis of AC and DC Side Harmonics of Three-Level Active Neutral Point Clamped Inverter with Space Vector Modulation**
Ruirui Chen[2], Jiahao Niu[2], Handong Gui[2], Zheyu Zhang[2], Fred Wang[2], Leon M. Tolbert[2], Benjamin J. Blalock[2], Daniel J. Costinett[2], Benjamin B. Choi[1]
[1]NASA Glenn Research Center, United States; [2]University of Tennessee, United States

11:40 a.m. – 12:00 p.m.

T02.9 **Identification of the DQ Impedance Model for Three-Phase Power Converter Considering the Coupling Effect of the Grid Impedance**
Hong Gong, Dongsheng Yang, Xiongfei Wang
Aalborg University, Denmark

8:30 a.m. – 12:00 p.m.

T03: Photovoltaic Power Conversion Systems

ROOM 213C

Renewable Energy Systems

CHAIRS:

Jian Sun, *RPI*

Yongheng Yang, *Aalborg University*

8:30 a.m. – 8:50 a.m.

T03.1 **Novel Dual-Mode Micro-Inverter for Photovoltaic AC Module Applications**
Feng Zhang[2], Yunxiang Xie[2], Yanshen Hu[1], Gang Chen[2], Xuemei Wang[2]
[1]MOSO Electric Co. Ltd., China; [2]South China University of Technology, China

8:50 a.m. – 9:10 a.m.

T03.2 **Current-Fed Z-Source Converter for Medium-Voltage Medium-Frequency Isolated Solar-Photovoltaic Systems**
Jose M. Sandoval, Victor Cardenas, Manuel A. Barrios, Mario Gonzalez
Universidad Autonoma de San Luis Potosi, Mexico

9:10 a.m. – 9:30 a.m.

T03.3 **Cost-Volume-Reliability Pareto Optimization of a Photovoltaic Microinverter**
Yanfeng Shen, Sungyoung Song, Huai Wang, Frede Blaabjerg
Aalborg University, Denmark

9:30 a.m. – 9:50 a.m.

T03.4 **A New Single-Switch, Electrolytic Capacitor-Less Step-Up DC/DC Converter Topology with Complete Soft-Switching Operation for Photovoltaic Application**
Kajanan Kanathipan, John Lam
York University, Canada

9:50 a.m. – 10:10 a.m.

T03.5 **Fundamental Switching Frequency Pulse Width Modulation of Nine-Level Current-Fed Multilevel Converter for Solar Application**
Gnana Kulothungan[2], Akshay Kumar Rathore[1], Dipti Srinivasan[2], Jose Rodriguez[3]
[1]Concordia University, Canada; [2]National University of Singapore, Singapore; [3]Universidad Andres Bello, Chile

10:10 a.m. – 10:40 a.m.

Break

10:40 a.m. – 11:00 a.m.

T03.6 **Power Pulsation Decoupling in a Series-Stacked PV-Battery Inverter**
Namwon Kim, Babak Parkhideh
University of North Carolina at Charlotte, United States

11:00 a.m. – 11:20 a.m.

T03.7 **Autonomous Power Reserve Control for Cluster of Photovoltaic Sources in Microgrids**
Silvanus Ashok D'Silva[1], Praneeth Nanduri[3], Sarthak Jain[2], Fariba Fateh[1], Mohammad B. Shadmand[1], Behrooz Mirafzal[1]
[1]Kansas State University, United States; [2]Renesas Electronics, United States; [3]Schlumberger Limited, United States

11:20 a.m. – 11:40 a.m.

T03.8 **Economically Optimal Power Flow Management of Grid-Connected Photovoltaic Microgrid Based on Dynamic Programming Algorithm and Grid I/O Strategy for Different Weather Scenarios**
Ya Guo[1], Su Sheng[2], Norma Anglani[3], Brad Lehman[1]
[1]Northeastern University, United States; [2]OSRAM, United States; [3]University of Pavia, Italy

11:40 a.m. – 12:00 p.m.

T03.9 **Modular Multilevel DC Cascaded Converter with Battery Electrical Storage Integration**
Mladen Gagic[1], Kewei Huang[2], Zian Qin[1], Bram Ferreira[1]
[1]Delft University of Technology, Netherlands; [2]Delft University of Technology, China

8:30 a.m. – 12:00 p.m.

T04: Control of DC-DC Converters

ROOM 213D

Control

CHAIRS:

Chao Fei, *Google*

Juncheng (Lucas) Lu, *GaN Systems*

8:30 a.m. – 8:50 a.m.

T04.1 **Sliding-Mode-Based Direct Power Control of Dual-Active-Bridge DC-DC Converters**
Kerui Li, Yun Yang, Siew-Chong Tan, Ron Shu Yuen Hui
University of Hong Kong, Hong Kong

8:50 a.m. – 9:10 a.m.

T04.2 **Modeling and Control of a Four-Port DC-DC Converter for a Hybrid Energy System**
Jianwu Zeng[1], Jiahong Ning[1], Taesic Kim[2], Vincent Winstead[1]
[1]Minnesota State University, Mankato, United States; [2]Texas A&M University-Kingsville, United States

9:10 a.m. – 9:30 a.m.

T04.3 **Unified Current-Programmed Digital Controller for Non-Inverting Buck-Boost Converter with Optimal Steady-State and Transient Conditions**
Tom Urkin, Mor Mordechai Peretz
Ben-Gurion University of the Negev, Israel

9:30 a.m. – 9:50 a.m.

T04.4 **An Integrated Regulated Resonant Switched-Capacitor DC-DC Converter for PoI Applications**
Giacomo Ripamonti[1], Stefano Michelis[1], Mario Ursino[2], Stefano Saggini[2], Federico Faccio[1]
[1]CERN, Switzerland; [2]University of Udine, Italy

9:50 a.m. – 10:10 a.m.

T04.5 **Simplified Optimal Trajectory Control for 1 MHz LLC Converter with Wide Input Voltage Range**
Ahmed Nabih, Mohamed H. Ahmed, Qiang Li, Fred C. Lee
Virginia Polytechnic Institute and State University, United States

10:10 a.m. – 10:40 a.m.

Break

10:40 a.m. – 11:00 a.m.

T04.6 **A Very Simple Analog Control for QSW-ZVS Source/Sink DC-DC Converters with Seamless Mode Transition**
Aitor Vazquez, Kevin Martin, Manuel Arias, Javier Sebastian
University of Oviedo, Spain

11:00 a.m. – 11:20 a.m.

T04.7 **Dynamic Interleaving of Multi-Phase Synchronous DC-DC Converters with ZVS**
M A Awal, Dhrubo Rahman, Yukun Luo, Wensong Yu, Iqbal Husain
North Carolina State University, United States

11:20 a.m. – 11:40 a.m.

T04.8 **Control of Independent-Input, Parallel-Output DC/DC Converters for Modular Battery Building Blocks**
Mohamed Kamel[2], Muneeb Rehman[2], Fan Zhang[1], Regan Zane[2], Dragan Maksimović[1]
[1]University of Colorado Boulder, United States; [2]Utah State University, United States

11:40 a.m. – 12:00 p.m.

T04.9 **Small Signal Analysis of Active Clamp Flyback Converters in Transition Mode and Burst Mode**
Pei-Hsin Liu
Texas Instruments Inc., United States

8:30 a.m. – 12:00 p.m.

T05: Drives & Inverters: Topologies & Control

ROOM 303AB

Motor Drives and Inverters

CHAIRS:

Arijit Banerjee, *University of Illinois Urbana-Champaign*

Karthik Jayaraman, *Dialog Semiconductor*

8:30 a.m. – 8:50 a.m.

T05.1 **Robust Floating Capacitor Voltage Control of Dual Inverter Drive for Open-Ended Winding Induction Motor**
Chatumal Perera, Siyu Leng, Gregory J. Kish, John Salmon
University of Alberta, Canada

8:50 a.m. – 9:10 a.m.

T05.2 **Coupled Inductor Design for Interleaved Three-Level Active Neutral Point Clamped Inverters Considering EMI Noise Reduction**
Ruirui Chen[2], Jiahao Niu[2], Handong Gui[2], Zheyu Zhang[2], Fred Wang[2], Leon M. Tolbert[2], Benjamin J. Blalock[2], Daniel J. Costinett[2], Benjamin B. Choi[1]
[1]NASA Glenn Research Center, United States; [2]University of Tennessee, United States

9:10 a.m. – 9:30 a.m.

T05.3 **A Minimum DC-Link Capacitance Estimation and Robust Voltage Control for an N-Phase Interleaved Boost Converter Supplying a Traction Inverter**
Rana Alizadeh[2], Sebastian Gomez Jorge[1], Juan Carlos Balda[2], Yue Zhao[2]
[1]Universidad Nacional del Sur, Argentina; [2]University of Arkansas, United States

9:30 a.m. – 9:50 a.m.

T05.4 **Voltage-Doubler Front-End Converter for Two-Quadrant Switched Reluctance Motor Drives**
Hung-Chi Chen[3], Meng-Sian Chen[1], Wei-Te Su[2]
[1]Chiao Tung University, Taiwan; [2]Delta Electronics Inc., Taiwan; [3]National Chiao Tung University, Taiwan

9:50 a.m. – 10:10 a.m.

T05.5 **Masterless Interleaving Scheme for Parallel-Connected Inverters Operating with Variable Frequency Hysteretic Current-Mode Control**
Samantha Murray, Miad Nasr, Mojtaba Ashourloo, Olivier Trescases
University of Toronto, Canada

10:10 a.m. – 10:40 a.m.

Break

10:40 a.m. – 11:00 a.m.

T05.6 **Ripple-Compensation Improvement of Direct Digital Controlled 3ϕ4W Grid-Connected Hybrid-Frequency Inverter System**
Tsai-Fu Wu, Yen-Hsiang Huang, Wei-Chi Cheng, Xiu-Ci Gao
National Tsing Hua University, Taiwan

11:00 a.m. – 11:20 a.m.

T05.7 **Two Degrees of Freedom Power Decoupling Method for Single-Phase Split-Source Inverter**
Changqing Yin, Zhen Xin, Lei Ming, Poh Chiang Loh
Chinese University of Hong Kong, Hong Kong

11:20 a.m. – 11:40 a.m.

T05.8 **Characterization and Implementation of Hybrid Reverse-Voltage-Blocking and Bidirectional Switches Using WBG Devices in Emerging Motor Drive Applications**
Hang Dai, Renato Amorim Torres, Thomas M. Jahns, Bulent Sarlioglu
University of Wisconsin-Madison, United States

11:40 a.m. – 12:00 p.m.

T05.9 **Pulse Energy Modulation for a Single-Phase Bridge Inverter with Power Decoupling Capability**
Shuang Xu, Liuchen Chang, Riming Shao
University of New Brunswick, Canada

8:30 a.m. – 12:00 p.m.

T06: Devices and Components I

ROOM 303CD

Devices and Components

CHAIRS:

Alex Huang, *Univ of Texas at Austin*

Pete Losee, *UnitedSiC*

8:30 a.m. – 8:50 a.m.

T06.1 **A Minimum Viable Mission Profile Emulator for IGBT Modules in Modular Multilevel Converters**
Zhongxu Wang, Huai Wang, Yi Zhang, Frede Blaabjerg
Aalborg University, Denmark

8:50 a.m. – 9:10 a.m.

T06.2 **Simplified Multi-Time Scale Thermal Model Considering Thermal Coupling in IGBT Modules**
Yi Zhang, Huai Wang, Zhongxu Wang, Frede Blaabjerg
Aalborg University, Denmark

9:10 a.m. – 9:30 a.m.

T06.3 **Comparison of Fast and Reliable Zero-Voltage Detection Topologies**
Steffen Beushausen, Jonas Krolzik, Johannes Voss, Rik W. De Doncker
RWTH Aachen University, Germany

9:30 a.m. – 9:50 a.m.

T06.4 **Impact of the Case Temperature on the Reliability of SiC MOSFETs Under Repetitive Short Circuit Tests**
He Du, Paula Diaz Reigosa, Francesco Iannuzzo, Lorenzo Ceccarelli
Aalborg University, Denmark

9:50 a.m. – 10:10 a.m.

T06.5 **Junction Temperature Measurement Based on Electroluminescence Effect in Body Diode of SiC Power MOSFET**
Chengmin Li[2], Zhebie Lu[2], Han Wu[2], Wuhua Li[2], Xiangning He[2], Shan Li[1]
[1]Shanghai Marine Equipment Research Institute, China; [2]Zhejiang University, China

10:10 a.m. – 10:40 a.m.

Break

10:40 a.m. – 11:00 a.m.

T06.6 **Condition Monitoring Method for Submodule Capacitor in Modular Multilevel Converter**
Hanyu Wang[2], Huai Wang[1], Yi Zhang[1], Zhongxu Wang[1], Xuejun Pei[2], Yong Kang[2]
[1]Aalborg University, Denmark; [2]Huazhong University of Science and Technology, China

11:00 a.m. – 11:20 a.m.

T06.7 **A Passive Transient Current Balancing Method for Multiple Paralleled SiC-MOSFET Half-Bridge Modules**
Sizhao Lu, Xiaoting Deng, Siqi Li, Enguo Rong
Kunming University of Science and Technology, China

11:20 a.m. – 11:40 a.m.

T06.8 **Comparative Study of Three Different Passive Snubber Circuits for SiC Power MOSFETs**
Shengsheng Liu, Hua Lin, Tao Wang
Huazhong University of Science and Technology, China

11:40 a.m. – 12:00 p.m.

T06.9 **650V GaN Based 3.3kW Bi-Directional DC-DC Converter for High Efficiency Battery Charger with Wide Battery Voltage Range**
Feng Qi, Zhan Wang, Yifeng Wu
Transphorm Inc., United States

8:30 a.m. – 12:00 p.m.

T07: Topologies for Grid-Tied Converters

ROOM 304AB

Power Electronics for Utility Interface

CHAIRS:

Suzan Eren, *Queen's University*

Majid Pahlevani, *University of Calgary*

8:30 a.m. – 8:50 a.m.

T07.1 **A Hybrid Snubber for Voltage-Balancing and Self-Powering of Series-Connected Devices**
Vinson Jones[2], Juan Carlos Balda[2], Rambabu Adapa[1]
[1]Electric Power Research Institute, United States; [2]University of Arkansas, United States

8:50 a.m. – 9:10 a.m.

T07.2 **Component Sizing and Voltage Balancing of MMC-Based Solid-State Transformers Under Various AC-Link Excitation Voltage Waveforms**
Lei Zhang[1], Jiangchao Qin[1], Qing Duan[2], Wanxing Sheng[2]
[1]Arizona State University, United States; [2]China Electric Power Research Institute, China

9:10 a.m. – 9:30 a.m.

T07.3 **A Modular Multilevel Hybrid Active Bridge DC-DC Converter Suitable for Medium-Voltage DC Distribution Grid**
Xingping Xu[1], Xuehua Wang[1], Xinbo Ruan[2], Yuan Xie[1]
[1]Huazhong University of Science and Technology, China; [2]Nanjing University of Aeronautics and Astronautics, China

9:30 a.m. – 9:50 a.m.

T07.4 **Single-Stage Multiport Capacitive-Link Universal Power Converter As a Solid-State Transformer for Nanogrid and Microgrid Applications**
Ehsan Afshari, Mahshid Amirabadi
Northeastern University, United States

9:50 a.m. – 10:10 a.m.

T07.5 **Current-Controlled Interlinking Converter with Grid-Supporting Functionalities**
Qing Liu, Tommaso Caldognetto, Simone Buso
University of Padova, Italy

10:10 a.m. – 10:40 a.m.

Break

10:40 a.m. – 11:00 a.m.

T07.6 **Selective Harmonic Compensation of Three Phase Grid Tied SEPIC Based Differential Inverter**
Ahmed Shawky, Mahmoud Abdallah Sayed, Takaharu Takeshita
Nagoya Institute of Technology, Japan

11:00 a.m. – 11:20 a.m.

T07.7 **Design of Interleaved Converters with Minimum Filtering Requirement**
Zhongyi Quan, Yun Wei Li, Changpeng Jiang
University of Alberta, Canada

11:20 a.m. – 11:40 a.m.

T07.8 **Flying-Capacitor Linear Amplifier with Capacitor Voltage Balancing Control for Efficient and Low Harmonic Power Conversion**
Tatsuki Ohno, Masaya Katayama, Hidemine Obara, Atsuo Kawamura
Yokohama National University, Japan

11:40 a.m. – 12:00 p.m.

T07.9 **Simplified Multilevel Hybrid Microgrids Using an Integrated AC-DC-DC Converter**
Javad Khodabakhsh, Gerry Moschopoulos
Western University, Canada

8:30 a.m. – 12:00 p.m.

T08: WideBand Gap Applications

ROOM 304CD

Power Electronics Applications

CHAIRS:

Pedro Alou, *Universidad Politecnica de Madrid*

Doug Osterhout, *Google Power Group*

8:30 a.m. – 8:50 a.m.

T08.1 **Design Considerations of High-Voltage-Insulated Gate Drive Power Supply for 10 kV SiC MOSFET in Medium-Voltage Application**
Li Zhang[2], Shiqi Ji[2], Shida Gu[2], Xingxuan Huang[2], James Everette Palmer[2], William Giewont[1], Fred Wang[2], Leon M. Tolbert[2]
[1]Danfoss Drives, United States; [2]University of Tennessee, United States

8:50 a.m. – 9:10 a.m.

T08.2 **Highly Efficient and Compact GaN-Based Tracking Power Supply System for Linear Power Amplifiers**
Vladan Lazarević[2], Iñigo Zubitur[2], Miroslav Vasić[2], Jesús Angel Oliver[2], Pedro Alou[2], Greg Patchin[1], Jens Eltze[1], José Antonio Cobos[2]
[1]Apex Microtechnology, United States; [2]Universidad Politécnica de Madrid, Spain

9:10 a.m. – 9:30 a.m.

T08.3 **A Reliable Ultra-Fast Three Step Short Circuit Protection Method for E-Mode GaN HEMTs**
Xintong Lyu[2], He Li[2], Yousef Abdullah[2], Jin Wang[2], Boxue Hu[2], Zhi Yang[2], Jin Wang[2], Liming Liu[1], Sandeep Bala[1]
[1]ABB Inc., United States; [2]Ohio State University, United States

9:30 a.m. – 9:50 a.m.

T08.4 **Benchmarking and Qualification of Gate Drivers for Medium Voltage (MV) Operation Using 10 kV Silicon Carbide (SiC) MOSFETs**
Anup Anurag[1], Sayan Acharya[1], Ghanshyamsinh Gohil[2], Subhashish Bhattacharya[1]
[1]North Carolina State University, United States; [2]University of Texas at Dallas, United States

9:50 a.m. – 10:10 a.m.

T08.5 **High-Frequency GaN-Based Induction Heating Versatile Module for Flexible Cooking Surfaces**
Hector Sarnago, Jose Miguel Burdío, Oscar Lucia
Universidad de Zaragoza, Spain

10:10 a.m. – 10:40 a.m.

Break

10:40 a.m. – 11:00 a.m.

T08.6 **Active Gate Control for Series Connected SiC MOSFETs**
Inhwan Lee, Xiu Yao
University at Buffalo, United States

11:00 a.m. – 11:20 a.m.

T08.7 **A Versatile Large-Signal High-Frequency Arbitrary Waveform Generator Using GaN Devices**
Hector Sarnago[2], Jose Miguel Burdío[2], Tomás García-Sánchez[1], Lluis M. Mir[1], Oscar Lucia[2]
[1]Paris-Sud University, Gustave Roussy, Université Paris- Saclay, France; [2]Universidad de Zaragoza, Spain

11:20 a.m. – 11:40 a.m.

T08.8 **Sequential Parallel Switching for Drain-Source Synchronous Rectifier Efficiency and Light-Load Stability Improvement**
Oscar Yu, Chih-Shen Yeh, Jih-Sheng Jason Lai
Virginia Polytechnic Institute and State University, United States

RAP SESSIONS

The APEC 2019 RAP Sessions feature several exciting and contentious topics. RAP Sessions allow for exciting dialogue amongst attendees and presenters. Admission to all Rap Sessions is free with an Exhibits Only Registration.

5:00 p.m. – 6:30 p.m.

RAP SESSION 1:
When Will WBG Have Significant Volume? Is the System Benefit Worth the Cost? Is WBG Reliable?

BALLROOM D

Session/Track

MODERATOR:

Alix Paultre, *Smartalix*

PANELISTS:

- **Sandeep Bala,** *ABB Corporate Research Raleigh*
- **Tim McDonald,** *Chairman of JEDEC JC 70.1*
- **Alex Lidow,** *EPC*
- **Jim Witham,** *GaN Systems*
- **Chris Dries,** *United SiC*
- **Filippo DiGiovanni,** *STMicroelectronics*

Now that the availability and performance of wide-bandgap semiconductors in the marketplace has been established, the focus is shifting from promise to reality. What application spaces face the most disruption? What opportunities are presenting themselves? The panel for this rap session includes manufacturers selling Silicon Carbide (SiC) and Gallium Nitride (GaN) components, and the companies designing their current and future products with them. What is the current state of the wide-bandgap industry? Come participate in our rap session and find out!

5:00 p.m. – 6:30 p.m.

RAP SESSION 2:
Power Supply On Chip (Pwr SoC) vs. Power Supply In Package (Pwr Sip) vs Discrete. What Is The Future?

BALLROOM C

Session/Track

MODERATOR:

Indumini Ranmuthu, *Texas Instruments*

SPEAKERS:

- **Hanh-Phuc Le,** *PwrSoC technical program chair (UC Boulder)*
- **Charlie Sullivan,** *Dartmouth University*
- **Sreenivasan Koduri,** *Texas Instruments Fellow*
- **Mohamed Jatlaoui,** *Murata*
- **James Doyle,** *Dialog Semiconductor*
- **Martin Haug,** *Wurth Elektronik*

There is significant trend in the industry towards higher power density and integration in power supplies. This integration has given rise to complex issues such as building complete power supplies on chip, 3D packaging for power supply in single package, highly miniaturized passives, thermal density and efficiency. The panelists for this session includes experts from actual design of power supply on chip, 3D packaging, design of miniaturized inductors and capacitors. Come participate, ask your questions from the experts and find out the state of the art!

5:00 p.m. – 6:30 p.m.

RAP SESSION 3

High Technology Holdup – Is Magnetics Really the Constraint or Are Magnetics Waiting for Everything Else to Catch Up?

BALLROOM B

Session/Track

MODERATOR:

Kevin Parmenter, *Taiwan Semiconductor NA*

SPEAKERS:

- **Ray Ridley,** *Ridely Engineering*
- **Steve Tom,** *Texas Instruments*
- **Dan Jitaru,** *Rompower*
- **Eric Persson,** *Infineon*
- **George Slama,** *Wurth*
- **Larry Spaziani,** *GaN systems*

Enormous efforts are being made to uncover new semiconductor technologies and circuit topologies to supply the ever-changing demands of modern electronics. At each step, magnetics seem to be there for those companies that understand how to design them properly. We will debate this and explore the constraints. Come and join this discussion about what we will need to be prepared for the next generation of power electronics.

EXHIBITOR SEMINARS as of March 1, 2019

APEC 2019 Exhibitor Seminars will highlight new products or initiatives that companies in the power electronics industry are developing, along with allowing the opportunity for attendees to interact with other companies in the industry.

1:30 p.m. – 2:00 p.m.

Exhibitor Seminars – Session #1

Analog Devices
ROOM 211AB

ADI's Power by Linear Portfolio: Silent Switchers & Micromodule Regulator Products

PRESENTED BY: **Tony Armstrong**

This seminar will cover some of the basics of buck regulator operation including how high di/dt and parasitic inductance in the switcher "hot" loop cause electro-magnetic noise and switch ringing. It will cover how to reduce the high frequency noise. PC-board layout is critical to the success or failure of very power supply design. It sets functional, electromagnetic interference and thermal behavior. While switching power supply layout is not black magic – it is often overlooked until it is too late in the design process. Therefore, it will discuss proven way to mitigate these potential threats of EMI generation from the onset will ensure a quiet power supply. Silent Switcher technology will be shown, showing how it is constructed and it will describe how it helps to solve EMI problems without any compromises. Silent Switcher packaging and layout and discuss how these can enhance the overall performance of the step-down converters. From here, micromodule regulators will be introduce, indicating how they are constructed with a description of the problems they solve. It will also cover their packaging trends and their quality levels. It will demonstrate their performance characteristic both from a thermal and form factor perspective, clearly showing their increasing power density in order to have a 100A output capable device in small footprint and able to deliver 100 Watts of power from 12V input to 1V output with 90 percent efficiency and only 200 LFM of air flow needed.

AVX
ROOM 212AB

MLCC and Tantalum Electrolytic Capacitor Interchangeability in High Capacitance Applications

PRESENTED BY: **Chris Reynolds**

Over the years, ceramic capacitors have been used interchangeably with tantalum in many digital applications, class II ceramics being the one electrostatic technology that can achieve the high capacitance values typically associated with electrolytic capacitors. We are currently at a point where more electrolytic designs are being re-considered for applications that had switched to class II ceramic in recent years. While most applications are amenable to such interchangeability, some parametric factors arise due to the differences in technology, so these need to be taken into consideration. This paper discusses the differences between electrostatic and electrolytic technologies, explaining the origin and effects of temperature and voltage coefficients, piezo and noise effects in class II ceramics, and polarity and ESR in solid tantalum electrolytic capacitors.

Infineon Technologies Americas Inc
ROOM 213C

Infineon's GaN & SiC devices for High Performance Power Electronic Applications

PRESENTED BY: **Steve Bakos**

Infineon will review the advancements in GaN and SiC, including the applications, performance advantages, design considerations as well as the importance of quality and reliability when considering these technologies in customer designs.

Microchip
ROOM 213D

Dual-core DSCs for Digital Power Conversion

PRESENTED BY: **Tom Spohrer**

Low-cost digital signal controllers (DSCs) that contain multiple processing cores add a new dimension for system partitioning in digital power applications. This session will highlight the features of Microchip's new dsPIC33CH family of dual-core DSCs and discuss various use cases for multi-core controllers.

Navitas Semiconductor

EXHIBIT HALL D SHOW FLOOR: THEATER 1

What Are You Waiting For? Let's Go GaNFast!

PRESENTED BY: **Stephen Oliver**

GaN has entered high-volume, mainstream production. End-customer products and roadmap applications from 24W to kW+ are highlighted. Then a 45W USB-PD fast-charger case-study details high-frequency GaNFast power IC technology, qualification 'beyond JEDEC', system schematic and layout, plus thermal and EMI (CE, RE) results. Discover how to become a GaNFast Design Partner!

ON Semiconductor

ROOM 303AB

Satisfying the Pressured Designer's Wish List with All the Right Tools in Just One Toolbox

PRESENTED BY: **Dave Priscak**

The modern electronics designer often has to be a jack of all trades - in SMEs and even mid-sized OEMs, he or she may need to design and develop solutions in analog or digital and effectively deal with challenging areas such as EMI, RFI and thermal management. This is a tough ask, made all the more difficult in an environment where available technology continues to move at a fast and exciting pace, enabling the ever-more diverse and amazing stream of end products that consumers and industry alike have grown used to having access to, but meaning the engineer is on a continuous learning curve. The final consideration to throw into the mix is time pressure - the fast moving technological environment means getting new ideas to market quickly is key to gaining market share and generating revenues from often short-lived USPs. All of this creates a comprehensive wish list from the pressured engineer. This article looks at the key items on such a notional list and considers how the tools, resources and information in the sector can help satisfy them.

Wurth Electronics

EXHIBIT HALL D SHOW FLOOR: THEATER 2

Avoid Designing Custom Magnetics by using REDEXPERT

PRESENTED BY: **George Slama**

Designing your own custom magnetics may seem like a good idea at first. After all, you'll get exactly what you want. But will you? Consider the time and effort that first goes into some type of design and then into procuring the necessary cores, bobbins, wire and later into actually winding and gapping the core. This also requires equipment since only the simplest inductors can be made by hand. The best performing magnetics generally use techniques (e.g. rectangular wire wound on edge) and materials (e.g. pressed composites) not available outside of manufacturing facilities. This session will show you why it makes sense to use standard magnetic components and how to take advantage of the wealth of performance information available to help verify your design. Based on actual testing, REDEXPERT gives you access to the world's most accurate ac loss measurements for inductors. Discover the broad of range of solutions available for next day delivery. Learn how to easily and quickly select the right inductor, flyback transformer or wireless power transfer coil for your application.

Tektronix

ROOM 303CD

Challenges with Testing Wide Band Gap Power Converters

PRESENTED BY: **Seshank Malap**

Wide Band Gap Converters are becoming mainstream across many applications in the field of power electronics to drive power density and efficiency. The design engineer is faced with increasingly complex challenges: navigating faster switching speeds, and minimizing parasitics to name just two.

It's very difficult to design and optimize these circuit when using improper measurement techniques and if the designer is not using the right measurement equipment.

This seminar will offer insights on common sources of measurement errors, tips on testing methods and example measurements which will help the designer test with greater accuracy, consistency, and reliability.

2:15 p.m. – 2:45 p.m.

Exhibitor Seminars – Session #2

Magnetics
ROOM 211AB

New Powder Core Materials for High Frequency and High Current

PRESENTED BY: **Mark Swihart**

Engineers find that powder cores are the best choice for many designs because of their high saturation and soft roll off with current. Even as application frequencies trend higher, powder cores continue to be the right answer in many cases. Optimized high frequency performance is essential, but "high frequency" means different things to different people. It could be 50 kHz, or 3 MHz, or anything in between. To meet the need for better overall efficiency and size across the whole range of frequencies, Magnetics has developed new materials and improved on existing ones, with more to come. In this session, the leader of Magnetics' R&D team will explain these new materials and what is coming in the pipeline.

Mitsubishi Electric US, INC
EXHIBIT HALL D SHOW FLOOR: THEATER 1

The LV100 and HV100 New Standard Modules for High Power Applications

PRESENTED BY: **Eric R. Motto**

This presentation will introduce the LV100 and HV100 new industry standard module packages for high power applications. Existing high power single modules in common 130mm x 140mm and 190mm x 140mm packages introduce a large stray inductance when series connected to form an inverter leg. This large inductance makes higher frequency operation and parallel connection challenging. Similarly, common large dual modules in 89mm x 250mm and 89mm x 172mm packages have significant internal asymmetries that cause undesirable current and temperature imbalance when the switching speed is increased. These problems become more pronounced with state of the art IGBT chips like Mitsubishi's 7th generation CSTBTTM (III) and practically unmanageable with SiC MOSFETs. Elimination of these limitations is the primary motivation for development of new high power modules having low and symmetric internal inductance with an optimized power terminal layout. This presentation will outline the characteristics, features, performance and line-up of these new modules.

Mouser
EXHIBIT HALL D SHOW FLOOR: THEATER 2

Silicon Carbide…A Brief Overview: Where We are, Where We're Headed, and Tips for Successful Use

PRESENTED BY: **Mitch Van Ochten**

Silicon Carbide continues to evolve but evolution also brings new challenges. We will take a look at the advancement in die size reduction, new packages with Kelvin connections, 4th Generation SiC roadmap and our new 1700V 250A Power Module that provides the industry's highest level of reliability while maintaining energy-saving performance. When integrating these new packages, there are many factors you should consider and we will provide guidance on choosing a Gate Driver, picking the DC/DC converter for the secondary side, minimizing stray inductance and checking for overshoot on the Gate voltage to optimize the design.

SIMPLIS Technologies
ROOM 212AB

SIMPLIS Magnetic Design Module and User C-code DLL Defined Digital Device

PRESENTED BY: **Tom Wilson** and **Andrija Stupar**

A digitally controlled PFC boost converter is modeled in SIMPLIS with the control algorithm defined by a user-generated C-code DLL. Placed on the schematic like any other SIMPLIS component, the device behavior is defined by C or C++ code rather than by logic gates and other digital circuit elements.

We then design the boost inductor and analyze its performance using the new SIMPLIS Magnetics Design Module – step-by-step, selecting the core, wire, winding arrangement, and cooling method. Results include core losses, detailed winding losses (including losses due to the air gap fringing flux), the inductance characteristic, and core and winding temperatures.

STMicroelectronics
ROOM 213C

Flexible Architectures to Efficiently Convert from 48V to Intermediate Bus or Directly to POL

PRESENTED BY: **Paolo Sandri**

48V DC bus power distribution poses challenges on conversion efficiency, power density and total BOM optimization. ST offers a rich set of architectures to better fit, virtually, any need when converting from 48V to either an intermediate bus or directly to POL. The architectures for the intermediate bus can either provide a regulated output or an unregulated one.

The 48V direct conversion architectures delivers power directly to the Digital ASIC, whose cores typically requires several hundred Watts and other key challenges needs to be addressed such as the compliance with the specific ASIC power needs with a certain degree of sophistication in term of accuracy and mode of operations.

Texas Instruments
ROOM 213D

Isolated Gate Drivers – How Do I Know Which One's Right for My Application?

PRESENTED BY: **Nagarajan Sridhar**

This seminar discusses the value of the isolated gate driver and explains how to pick the right isolated gate driver for high-power, high-voltage applications. Additionally, this seminar explores various functionality requirement modifications needed for applications trending toward the adoption of wide bandgap power devices such as SiC and GaN.

United Chemi-Con, Inc.
ROOM 303AB

Advanced Capacitor Technology for Automotive Applications

PRESENTED BY: **Derrick Fitzpatrick**

Updated hybrid capacitor series for high power DC link and also latest technology products line up will be presented.

Yokogawa
ROOM 303CD

The Next Generation in Power Measurement

PRESENTED BY: **Daniel Kasamis**

The WT5000 is the Next Generation in Precision of Yokogawa's Power Analyzers product line. It is a versatile platform that delivers extraordinary precision and exceptional performance for the most demanding applications. Equipped with 7 user swappable and reconfigurable input elements plus 4 motor channels, the WT5000 is an ideal instrument for both electrical and mechanical power and efficiency measurements. Its highly responsive touchscreen, intuitive menu operations, and out of the box software solution make the WT5000 an ideal instrument for your testing needs. We will be highlighting key applications for motor and drive development, renewable energy, and inductive charging.

3:00 p.m. – 3:30 p.m.

Exhibitor Seminars – Session #3

Alpha and Omega Semiconductor
EXHIBIT HALL D SHOW FLOOR: THEATER 2

A New Compact SMD-Type Intelligent Power Module

PRESENTED BY: **In-Wha Jeong**

This seminar presents a new dual-in-line surface-mount device (SMD)-type intelligent power module (IPM7) solution specialized for low power motor drives applications such as fan motors of air-conditioning systems, which require highly compact size with reliable and efficient design allowance.

CogniPower
ROOM 211AB

Simplifying Efficient Low Power AC/DC Converters

PRESENTED BY: **Tom Lawson**

Ultra-efficient, small AC/DC converters can be surprisingly simple. We achieve 96% efficiency at 10% of full load in a power converter capable of several watts output. Transient response is excellent and cost can be competitive with the lowest- cost alternatives. The approach scales from under 1 Watt to 65 Watts Secondary-side control enables easy and direct digital interfacing. Adding CogniPower Compound Converter Technology removes the upper limit. Circuit details will be provided.

Efficient Power Conversion Corporation (EPC)
ROOM 212AB

GaN's Frontal Assault on Silicon at 48 Volts

PRESENTED BY: **Alex Lidow Ph.D.**

In the past nine years, GaN-on-Si transistors and integrated circuits have enabled many extraordinary new applications such as LiDAR for autonomous cars, wireless power, and envelope tracking. GaN integrated circuits have started to appear in USB-C adapters, UPS systems, drones, and a host of medical devices. But the promise that GaN will crush silicon has not yet been fulfilled, until now. With pricing of 100 V GaN transistors equally commercial power MOSFETs, coupled with their large performance advantages, there has been a groundswell of GaN adoption occurring at 48 V input DC-DC power supplies used in everything from AI machines, high-end servers, gaming machines, and now cars. In this seminar, we will look at the front line of this adoption wave by showing examples of systems and quantifying the performance and cost edge GaN devices bring to the customer.

Fuji Electric Corp. of America
ROOM 213C

Introduction of RC-IGBT

PRESENTED BY: **Alexander Theisen**

High-efficiency energy usage has become an extremely important factor in achieving a low-carbon society. A key to curbing the emissions of CO2- a major cause of global warming - is to take effective measures in the development of the power electronics devices used in the control of electric energy. Fuji Electric has developed and commercialized power semiconductors, which contribute to an overwhelming downsizing and efficiency improvement of power electronics equipment. In this session, we would like to present our 7th-Generation "X Series" RC-IGBT (Reverse Conduction IGBT) technology and industrial applications.

Mersen
ROOM 213D

Improving Safety & Reliability for Power Electronics

PRESENTED BY: **Kian Sanjari**

Session presents Mersen's commitment to develop industry leading technologies to improve efficiency and reliability of power electronics equipment. Key topics include an Overview of High Speed Protection Fuses and innovative hybrid DC overcurrent protection devices for EV/EES applications. We will explain how Air and Liquid Cooling solutions provide thermal protection for semiconductor components and that efficient cooling is key to long term reliability and performance of fast switching semiconductor components. We will also present how laminated bus bars provide the most efficient connection between various components, thus limiting parasitic inductance, improving ease of assembly and integration while minimizing wiring errors and costs.

Panasonic
ROOM 303AB

X-GaN Power Transistor Breakdown Mechanisms

PRESENTED BY: **Tom Higuchi**

GaN, which surpasses Si by performance, is increased its expectation as a next generation device.

The high performance of GaN has already been proved in many parties. So how about destruction?

The most important performance of Power Device is breakdown capability, GaN breakdown mechanisms will be clear in this seminar.

Rogers Corporation
EXHIBIT HALL D SHOW FLOOR: THEATER 1

Curamik ceramic substrates and laminated busbars solutions for Power Electronics

Presented by: **Dominik Pawlik** and **Olivier Mathieu**

Introduction to ceramic substrates and laminated busbars solutions from Rogers Corporation.

TT Electronics
ROOM 303CD

OPB9000 and Adaptable Sensors: Trends, Challenges and Developments

PRESENTED BY: **Sergey Komarov**

Modern day sensors applications in portable medical devices, wearables, appliances, drones and autonomous vehicles pose new challenges for product designers and sensors developers. While the traditional purpose of optical sensors as motion or position transducers for non-contacting object sensing fundamentally has not changed, the variety of environments in which they operate and demand for portability in a data driven world place new requirements for sensors to become highly integrated and dynamically adaptable. The OPB9000 reflective optical sensor from TT Electronics is one such device. It integrates an infrared (IR) emitter and a photodetector in one package, along with the analogue front-end circuitry, on-chip processing, and a digital interface in a surface-mount package of 4.0 × 2.2 × 1.5 mm. The circuitry is encapsulated in industrial resin, making it robust and able to operate at temperatures from –40 to +85 °C. In this session we will review the main trends, challenges and developments associated with adoptable sensors and their implementation in OPB9000.

3:45 p.m. – 4:15 p.m.

Exhibitor Seminars – Session #4

Holy Stone International
ROOM 211AB

Filling in the Multilayer Ceramic Capacitor Gap

PRESENTED BY: **Tom Stoddard**

Filling in the Gap" is a presentation where we will discuss Multi-layer Ceramic Capacitor products that have been de-emphasized or even dropped by some of the largest MLCC manufacturers. Holy Stone Enterprise Company focuses on many of these products providing an alternate source for some of these difficult capacitors to find. Holy Stone has long been a leader in Safety Certified and High C/V MLCC's which are precisely the area's where many manufacturers are de-emphasizing or dropping these products entirely.

Littelfuse, Inc.
ROOM 212AB

Innovative Packaging Plans for Littelfuse SiC Devices

PRESENTED BY: **Christophe Warin**

This presentation will focus on future packaging plans for Littelfuse SiC devices. Details to be discussed include optimization of SiC device performance in standard and innovative discrete packages as well as exploring other packaging options that include surface mount power devices (SMPD) and standard industry power modules.

Nichicon (America) Corp
ROOM 213D

New Small Li-Ion Rechargeable Batteries in a Capacitor Package

PRESENTED BY: **Mark Gebbia**

Nichicon is introducing a new product segment, the Small Lithium Ion Rechargeable Battery. The batteries bridge the gap between standard Lithium ion batteries and EDLC's. They have better energy capabilities than EDLC's and higher power characteristics than rechargeable Li-ion batteries. They are available in case sizes as small as 3x7mm and energy densities reaching 39 Wh/kg. These batteries are safer than conventional Li-ion batteries even at charge/discharge rates of 20C and do not ignite from shorting internally. Come and see us for more information and stop by Booth 665 for details.

Pacific Sowa Corp C/O Epson Atmix Corp
Room 303AB

High Reliability Soft Magnetic Powder for Automotive Inductors

PRESENTED BY: **Yoshizawa Masahito**

High reliability under sever conditions like engine rooms is required in automotive inductors. We introduce brand-new insulated soft magnetic powder for the automotive inductors by our original insulation technology. The key factor is stability under thermal aging conditions at 150C for 1000 hours with higher heat resistance and lower hygroscopicity than our conventional technologies. The insulation treatment is available for all our powders.

Ridley Engineering, Inc.
EXHIBIT HALL D SHOW FLOOR: THEATER 2

Magnetics Modeling and Software

PRESENTED BY: **Dr. Ray Ridley**

In this session, Dr. Ridley will show how magnetics structures can be quickly and accurately translated into LTspice models. The modeling techniques allow engineers to take their magnetics design to the next level. Powerful software algorithms solve for advanced proximity losses, giving far more accurate estimations of magnetics winding loss. The winding loss models will automatically adapt to the current waveforms seen by any given topology. For the first time, we also show how magnetics core loss can be incorporated into LTspice models for a given core and winding arrangement. The equivalent circuit models react to changing duty cycles and frequency components, automatically showing how the core loss changes. The reduction in development time is substantial.

SBE, Inc.
ROOM 303CD

Optimal DC Link Topologies for Best Utilization of Switch Modules

PRESENTED BY: **Michael Brubaker**

Advanced Si and SiC switch modules require an optimized DC link to enable maximum performance. SBE's integrated capacitor/bus technology is ideally suited for obtaining very low ESL and paralleling multiple half-bridges. Examples of next generation switch modules combined with ring capacitor windings surface mounted to low inductance bus structures are provided. This approach allows for the highest possible Ampere per micro-Farad rating of the DC link along with the lowest possible commutation loop inductance. Lowering the total ESL is critical to increase the operating voltage for improved efficiency and the best utilization of switching devices.

Siemens PLM

ROOM 213C

Improving Power Module Thermal Design & Reliability with IGBT Testing & Automatic Calibration of Simulation Models

PRESENTED BY: **Andras Vass-Varnai** and **Joe Proulx**

For compact design of power electronics modules, thermal management at component to module level must be evaluated for optimal performance and reliability. This presentation introduces a study of multiple thermal measurements of IGBT power semiconductors within a power module, followed by calibration of detailed compact thermal models for use in improving the system level electronic cooling simulation accuracy of the module. This approach combines use of Simcenter T3STER thermal transient measurement technology for heat flow path analysis and thermal reliability assessment respectively in conjunction with automatic detailed package model calibration and subsequent system level thermal simulation possible with Simcenter Flotherm software.

Schunk Carbon technology GmbH

EXHIBIT HALL D SHOW FLOOR: THEATER 1

Advanced Solutions for Energy Storage and Heat Dissipation Issues in Power Electronics

PRESENTED BY: **Dr. Sandra Reisinger**

The composite, Aluminium Graphite (ALG), has a low density paired with a high thermal conductivity and low coefficient of thermal expansion. This makes it the ideal thermal management material for high-reliability RF, power and microelectronics applications. Schunk produces a wide range of customized parts with different plating options in various quantities. Furthermore, ALG soldering jigs and fixtures can be produced far much more sophisticated features compared to conventional graphite jigs and offer the advantage of higher durability. Our innovative phase change composite, Latent Heat Carbon, allows for effective buffering of temperature peaks as well as energy storage. Its unique production process allows for custom designs at attractive cost with optimal thermal properties tailored to each customer's specific needs. Applications range from battery thermal management and climate control/HVACs in vehicles to electronics cooling.

INDUSTRY SESSIONS

At APEC 2019, the Industry Sessions track continues to expand. This track runs in parallel with the traditional Technical Sessions Track Speakers are invited to make a presentation only, without submitting a formal manuscript for the APEC Proceedings. This allows APEC to present information on current topics in power electronics from sources that would not otherwise be present at an industry conference. While many of these sessions are technical in nature, some also target business-oriented people such as purchasing agents, electronic system designers, regulatory engineers, and other people who support the power electronics industry. Presentations will be available through the APEC mobile app.

8:30 a.m. – 1010 a.m.

IS06: GaN in the Data center

ROOM 210BC

CHAIRS:

Mikhail Guz, *IP and Technology Experts LLC*

Nick Fichtenbaum, *Navitas Semi*

8:30 a.m. – 8:55 a.m.

IS06.1 **High Voltage GaN Devices in Server Power**
Ross Fosler
NexGen Power Systems Inc, United States

8:55 a.m. – 9:20 a.m.

IS06.2 **Evaluation of Symmetrical and Asymmetrical Scaling GaN FETs in High Step-Down Ratio Half Bridge Converters**
Jianjing Wang, Edward Jones, Michael de Rooij
Efficient Power Conversion Corporation, United States

9:20 a.m. – 9:45 a.m.

IS06.3 **Thermal Design for a High Density GaN-Based Power Stage**
Edward Jones
Efficient Power Conversion Corporation, United States

9:45 a.m. – 10:10 a.m.

IS06.4 **eGaN based High-Density Unregulated 48 V to x V LLC Converters with ≥ 98% Efficiency for Future Data Centers**
Mohamed Ahmed[1], Michael de Rooij[2], Fred C. Lee[1], Qiang Li[1]
[1]CPES Virginia TEch, United States; [2]Efficiecnt Power Conversion, United States

8:30 a.m. – 10:10 a.m.

IS07: Devices and Controllers in Adapter Application

ROOM 209AB

CHAIR:

Dennis Stephens, *Continental Automotive*

8:30 a.m. – 8:55 a.m.

IS07.1 **EZDrive℠ Solution for GaN E-HEMT in Adapter Applications**
Yajie Qiu, Juncheng Lu
GaN Systems Inc., Canada

8:55 a.m. – 9:20 a.m.

IS07.2 **USB Type-C™ and Power Delivery ≤ 100W**
Deric Waters, Indumini Ranmuthu
Texas Instruments, United States

9:20 a.m. – 9:45 a.m.

IS07.3 **Adaptive Digital Synchronous Rectification for Power Supply Applications**
Ivan Massimiani
STMicroelectronics, Italy

9:45 a.m. – 10:10 a.m.

IS07.4 **Advanced Active Clamp Flyback Control for High-Density AC/DC Adapters**
Bing Lu
Texas Instruments, United States

8:30 a.m. – 10:10 a.m.

IS08: Design Considerations And A Deep Dive Into Capacitor Technologies

ROOM 210A

CHAIRS:

Wilmer Companioni, *Companioni*

Fred Weber, *Future Technologies Worldwide*

8:30 a.m. – 8:55 a.m.

IS08.1 **Reaching Higher Temperatures with Film Capacitors**
Rob Haywood
GORE, United States

8:55 a.m. – 9:20 a.m.

IS08.2 **Electrolytic Capacitors That Can Stand The Heat**
Scott Franco
Cornell Dublier, United States

9:20 a.m. – 9:45 a.m.

IS08.3 **Will The Real Supercapcitor Please Stand Up?**
Stephan Menzel
Wurth Electronics, United States

9:45 a.m. – 10:10 a.m.

IS08.4 **Class 1 Ceramic Technologies for Higher Power Density Converter Applications**
Mark Laps
KEMET Electronics, United States

8:30 a.m. – 10:10 a.m.

IS09: Modules

ROOM 210D

CHAIR:

David Levett, *Infineon*

8:30 a.m. – 8:55 a.m.

IS09.1 **Improved Thermal Performance for CIPOS™ Nano Intelligent Power Modules with Carbon Fiber Thermal Interface Material**
Pengwei Sun[2], Hiroyuki Ryoson[1]
[1]Dexerials Corp, Japan; [2]Infineon Technologies, United States

8:55 a.m. – 9:20 a.m.

IS09.2 **Mitsubishi Transfer Molded DIPIPMs**
Michael Rogers, John Donlon
Mitsubishi Electric US, United States

9:20 a.m. – 9:45 a.m.

IS09.3 **A Modular and Scalable High Performance Power Module for Silicon Carbide Devices**
Brice McPherson, Marcelo Schupbach, Sayan Seal, Atanu Dutta, Brandon Passmore, Alex Lostetter, Ty McNutt, Jeff Casady
Wolfspeed, A Cree Company, United States

9:45 a.m. – 10:10 a.m.

IS09.4 **A Medium Voltage (10 kV), Low Inductance, SiC Power Module for Next-Generation Electric Power Distribution Applications**
Zach Cole, Steven Ericksen, Jonathan Hayes, Jon Kelly, Kraig Olejniczak, Brandon Passmore, Ty McNutt, Andrew Lemmon, Marshall Olimmah
Wolfspeed, United States

8:30 a.m. – 10:10 a.m.

IS10: Wireless

ROOM 213B

CHAIRS:

Peter Di Maso, *GaN Systems*

Deepak Veereddy, *Infineon Technologies*

8:30 a.m. – 8:55 a.m.

IS10.1 **Coil Selection for Wireless Power Transfer**
Anantpreet Singh Aulakh
Würth Electronics, United States

8:55 a.m. – 9:20 a.m.

IS10.2 **Improving Efficiency in Highly Resonant Wireless Power Systems**
Michael de Rooij, Yuanzhe Zhang
Efficient Power Conversion Corporation, United States

9:20 a.m. – 9:45 a.m.

IS10.3 **50W to 1kW Wireless Power Transfer Implementation**
Tiefeng Shi
GaN Systems, Canada

9:45 a.m. – 10:10 a.m.

IS10.4 **Qi Power Control Principles and Consequences on PTx Design**
Christian Beia, Lionel Cimaz
STMicroelectronics, Italy; STMicroelectronics, France

2:00 p.m. – 5:25 p.m.

IS11: Current Reliability & Product Qualification Topics for SiC & GaN Wide Band Gap Devices

ROOM 210D

CHAIRS:

Edward Jones, *Efficient Power Conversion Corporation*

Tirthajyoti Sarkar, *On Semi*

2:00 p.m. – 2:25 p.m.

IS11.1 **Update on GaN and SiC Activities within JEDEC JC-70 Committee**
Jeffrey Casady[2], Stephanie Butler[1]
[1]Texas Instruments, United States; [2]Wolfspeed, United States

2:25 p.m. – 2:50 p.m.

IS11.2 **Meeting Industry Requirements for GaN Device Reliability**
Tim McDonald
International Rectifier, United States

2:50 p.m. – 3:15 p.m.

IS11.3 **650V GaN HEMT Reliability for Automotive Applications**
Ronald Barr
Transphorm, United States

3:15 p.m. – 3:40 p.m.

IS11.4 **Systematic Approach to GaN Power IC Reliability**
Darshan Gandhi
Navitas Semiconductor, United States

3:40 p.m. – 4:10 p.m.

Break

4:10 p.m. – 4:35 p.m.

IS11.5- **Performance, Reliability and Yield Considerations in State-of-the-Art SiC Diode and MosFET Technologies During Ramp-Up**
Thomas Neyer
ON Semiconductor, Germany

4:35 p.m. – 5:00 p.m.

IS11.6 **SiC Device Reliability**
Don Gajewski
Wolfspeed, United States

5:00 p.m. – 5:25 p.m.

IS11.7 **GaN Reliability for Automotive: Testing Beyond AEC-Q**
Robert Strittmatter
Efficient Power Conversion, United States

2:00 p.m. – 5:25 p.m.

IS12: Making Power Sources Small with 3D Power Packaging Solutions

ROOM 210A

CHAIR:

Brian Narveson, *Narveson Innovative Consulting*

2:00 p.m. – 2:25 p.m.

IS12.1 **Advanced Materials, Designs and 3D Package Architectures for Next-Gen High-Power Packaging**
Venessa Smet
Georgia Tech, United States

2:25 p.m. – 2:50 p.m.

IS12.2 **Thermal Modeling Challenges for Multilayer Ceramic Capacitors (MLCCs) in High Power Density Assemblies**
Allen Templeton
Kemet Electronics Corp., United States

2:50 p.m. – 3:15 p.m.

IS12.3 **Packaging Considerations in a High Power Density Inverter**
Alan Mantooth
University of Arkansas, United States

3:15 p.m. – 3:40 p.m.

IS12.4 **10A DC-DC Point-of-Load Power Modules with Integrated Inductors and Capacitors less than 1.0mm Height for Mobile Platforms**
Taner Dosluoglu
Endura Technologies, United States

3:40 p.m. – 4:10 p.m.

Break

4:10 p.m. – 4:35 p.m.

IS12.5 **Application of the PCB-Embedding Technology to a 3.3 kW Power Factor Corrector**
Rémy Caillaud[1], Johan Le Leslé[2], Cyril Buttay[1], Florent Morel[1], Roberto Mrad[2], Nicolas Degrenne[2], Stefan Mollov[2]
[1]Ampere Lab, Centre National de la Recherche Scientifique, France; [2]Mitsubishi Electric Research Centre Europe, France

4:35 p.m. – 5:00 p.m.

IS12.6 **Efficient Grid-to-Battery Power Electronics for EVs**
Kraig Olejniczak[2], Zach Cole[2], Jonathan Hayes[2], Dan Martin[2], Chad O'Neal[2], Ty McNutt[2], Jeff Casady[2], Dave Grider[2], Edward VanBrunt[2], John Palmour[2], Andrew Lemmon[1], M. Olimmah[1]
[1]University of Alabama, United States; [2]Wolfspeed, United States

5:00 p.m. – 5:25 p.m.

IS12.7 **Realization of High Electrical Performance on-Chip Magnetic and Thick Cu Inductor Package: Process Challenges and Solutions**
Ting-Li Yang
TSMC, Taiwan

2:00 p.m. – 5:25 p.m.

IS13: Gate Drive

ROOM 209AB

CHAIRS:

Kevin Parmenter, *Taiwan Semiconductor*

Jim Spangler, *Independent*

2:00 p.m. – 2:25 p.m.

IS13.1 **Cost Down of Gate Drive for SiC MOSFETs**
Yuequan Hu, Jianwen Shao
Wolfspeed, United States

2:25 p.m. – 2:50 p.m.

IS13.2 **A Practical Approach to Reliable High Power Switching Circuit with Isolated Gate Driver**
Long Nguyen
Silicon Laboratories, United States

2:50 p.m. – 3:15 p.m.

IS13.3 **Proposal for a High-Speed SiC MOSFET Switching Drive Method**
Seiya Kitagawa
ROHM Semiconductor, Japan

3:15 p.m. – 3:40 p.m.

IS13.4 **Mixed-Signal, CMOS Isolation: State-of-the-Art and Applications**
Kevin Kilbane
Silicon Labs, United States

3:40 p.m. – 4:10 p.m.

Break

4:10 p.m. – 4:35 p.m.

IS13.5 **EV/HEV Automotive Power Modules Packaging**
Elena Barbarini
System Plus Consulting, France

4:35 p.m. – 5:00 p.m.

IS13.6 **Photonic Isolated Power Products for Fast Switching, Low Noise Gate Drivers**
Mico Perales, Cheng-Liang Wu, Mei-Huan Yang, Kun-Hsien Chen
MH GoPower Company Limited, United States; MH GoPower Company Limited, Taiwan

5:00 p.m. – 5:25 p.m.

IS13.7 **Silicon Carbide Gate Driver Dependencies and Methods to Minimize Impact of Parasitics**
Derek Wilson, Nitesh Satheesh
AgileSwitch, LLC, United States

2:00 p.m. – 5:25 p.m.

IS14: Enablers for Transportation Electrification

ROOM 210BC

CHAIRS:

Fred Weber, *Future Technologies Worldwide*

Ralph Taylor, *Delphi Technologies*

2:00 p.m. – 2:25 p.m.

IS14.1 **3D Printing for Power Electronics and Electric Motors**
Burak Ozpineci
ORNL, United States

2:25 p.m. – 2:50 p.m.

IS14.2 **Novel Metal-Carbon Materials Called Covetics**
Iwona Jasiuk
University of Illinois at Urbana-Champaign, United States

2:50 p.m. – 3:15 p.m.

IS14.3 **Silicon Carbide Inverter Development, Inverter Testing and Findings from Heavy-Duty Vehicle**
Brij Singh
John Deere, United States

3:15 p.m. – 3:40 p.m.

IS14.4 **Holistic Thermal Management**
Kevin Bennion, Emily Cousineau, Bidzina Kekelia, Gilberto Moreno, Paul Paret
NREL, United States

3:40 p.m. – 4:10 p.m.

Break

4:10 p.m. – 4:35 p.m.

IS14.5 **Electrification Recycling**
Chris Whaling
Synthesis Partners, United States

4:35 p.m. – 5:00 p.m.

IS14.6 **Enabling Ultra-fast Charging of EVs with 3D Silicon Anode Structures in Lithium Batteries**
John Busbee
Xerion, United States

5:00 p.m. – 5:25 p.m.

IS14.7 **Beyond Conventional Wireless Power Transfer and Education of Electrification Engineers**
Charles Sullivan
Thayer School of Engineering at Dartmouth, United States

2:00 p.m. – 5:25 p.m.

IS15: Making the Battery Outlive the Device it Powers

ROOM 213B

CHAIRS:

Mike Hayes, *Tyndall National Institute*

Brian Zahnstecher, *PowerRox LLC*

2:00 p.m. – 2:25 p.m.

IS15.1 **Perspectives on Energy Harvesting for Aerospace Sensors**
Stephen Savulak
UTRC, United States

2:25 p.m. – 2:50 p.m.

IS15.2 **Microwatts AC-DC Conversion IC Design for Vibration and RF Energy Harvesting**
Wensi Wang, Jiaqi Yu
BJUT, China

2:50 p.m. – 3:15 p.m.

IS15.3 **A System on Chip for Energy Harvesting and Wireless Power Transfer**
Roberto La Rosa
STMicroelectronics, Italy

3:15 p.m. – 3:40 p.m.

IS15.4 **Batteryless Monitoring System for Real-World Automotive Applications**
Marcus Taylor
Silent Sensors, United Kingdom

3:40 p.m. – 4:10 p.m.

Break

4:10 p.m. – 4:35 p.m.

IS15.5 **Solving the Energy Harvesting and IoT Power Consumption Measurement Challenges**
Pat Hensley
Tektronix, United States

4:35 p.m. – 5:00 p.m.

IS15.6 **Powering IoT Edge Devices: A Story of EnerHarv and the Birth of an Ecosystem**
Francesco Carobolante[1], Brian Zahnstecher[2]
[1]IoTissimo, United States; [2]PowerRox, United States

TECHNICAL SESSIONS

APEC professionals like you participated in a rigorous peer review process and have carefully picked over 500 papers making up APEC's Technical Sessions. The review process highlights the most innovative technical solutions, and provides the highest quality possible. The technical program includes papers of broad appeal scheduled for oral presentation from Tuesday morning through Thursday afternoon. Papers with a more specialized focus are available for discussion with authors at the dialogue session on Thursday from 11:30 a.m. – 2:00 p.m. The various technical venues cover all areas of technical interest to the practicing power electronics professional. The papers are sure to give you many new design ideas that you can apply to your work immediately.

8:30 a.m. – 10:10 a.m.

T09: Converters for Data Centers

ROOM 211AB

DC-DC Converters

CHAIRS:

Robert Pilawa-Podgurski, *University of California, Berkeley*

Xin Zhang, *IBM*

8:30 a.m. – 8:50 a.m.

T09.1 **High-Efficiency, High-Density Isolated/Regulated 48V Bus Converter with a Novel Planar Magnetic Structure**
Mohamed H. Ahmed, Ahmed Nabih, Fred C. Lee, Qiang Li
Virginia Polytechnic Institute and State University, United States

8:50 a.m. – 9:10 a.m.

T09.2 **DC-UPS Capability for the SCALDO-Assisted 48-V Google Rack Power Architecture**
Thilanga Ariyarathna, Nihal Kularatna, D. Alistair Steyn-Ross
University of Waikato, New Zealand

9:10 a.m. – 9:30 a.m.

T09.3 **A 99% Efficient Dual-Phase Resonant Switched-Capacitor-Buck Converter for 48 V Data Center Bus Conversions**
Stefano Saggini[2], Shuai Jiang[1], Mario Ursino[2], Chenhao Nan[1]
[1]Google Platforms, United States; [2]University of Udine, Italy

9:30 a.m. – 9:50 a.m.

T09.4 **A Transformer-Less Quadruple Active Half-Bridge Converter for the Two-Stage 48V VRM Application**
Somnath Khatua, Debaprasad Kastha, Santanu Kapat
Indian Institute of Technology Kharagpur, India

9:50 a.m. – 10:10 a.m.

T09.5 **Dynamic Bus Voltage Configuration in a Two-Stage Multi-Phase Buck Converter to Mitigate Transients**
Arnab Acharya, Inder Kumar, Santanu Kapat
Indian Institute of Technology Kharagpur, India

8:30 a.m. – 10:10 a.m.

T10: Power Device and Module Modeling

ROOM 212AB

Modeling and Simulation

CHAIRS:

Sandeep Bala, *ABB*

Rolando Burgos, *Virginia Tech*

8:30 a.m. – 8:50 a.m.

T10.1 **An Electro-Thermo-Mechanical Model Basing on Experimental Results for Press-Pack IGBT Including MOS Side Two-Dimensional Effects**
Miaosong Gu[1], Xiang Cui[1], Xinling Tang[2], Cheng Peng[1], Zhibin Zhao[1]
[1]North China Electric Power University, China; [2]State Grid Smart Grid Research Institute, China

8:50 a.m. – 9:10 a.m.

T10.2 **Corner and Statistical SPICE Model Generation for Shielded-Gate Trench Power MOSFETs Based on Backward Propagation of Variance**
Yunpeng Xiao, James Victory, Scott Pearson, Tirthajyoti Sarkar, Ashok Challa, Marc Dagan, Paul Collanton, Cristian Andreev
ON Semiconductor, Germany; ON Semiconductor, China; ON Semiconductor, United States

9:10 a.m. – 9:30 a.m.

T10.3 **New Dynamic Power MOSFET Model to Determine Maximum Device Operating Frequency**
Adam Morgan, Ajit Kanale, Kijeong Han, Jayant Baliga, Douglas Hopkins
North Carolina State University, United States

9:30 a.m. – 9:50 a.m.

T10.4 **A Datasheet-Based Behavioral Model of SiC MOSFET for Power Loss Prediction in Electromagnetic Transient Simulation**
Yanming Xu[2], Carl Ngai Man Ho[2], Avishek Ghosh[2], Dharshana Muthumuni[1]
[1]Manitoba HVDC Research Centre, Canada; [2]University of Manitoba, Canada

9:50 a.m. – 10:10 a.m.

T10.5 **Cancellation of Leakage Currents Through Power Module Baseplate Capacitance**
Aaron Brovont, Andrew Lemmon, Christopher New, Blake Nelson, Brian Deboi
University of Alabama, United States

8:30 a.m. – 10:10 a.m.

T11: Microgrids Applications

ROOM 213C

Renewable Energy Systems

CHAIRS:

Zeng Liu, Xi'an *Jiaotong University*

Haoyu Wang, *ShanghaiTech University*

8:30 a.m. – 8:50 a.m.

T11.1 **Enhanced Voltage Regulation of AC Microgrids with Electric Springs**
Yufei He, Minghao Wang, Zhao Xu
Hong Kong Polytechnic University, Hong Kong

8:50 a.m. – 9:10 a.m.

T11.2 **A Synchronous Reference Frame Based Decentralized Control Architecture for Inverters Connected to an Autonomous Microgrid**
Subhrasankha Ghosh, Souvik Chattopadhyay, Sayan Samanta
Indian Institute of Technology Kharagpur, India

9:10 a.m. – 9:30 a.m.

T11.3 **Operation of a Flexible Dynamic Boundary Microgrid with Multiple Islands**
Shuying Zhen[1], Yiwei Ma[2], Fred Wang[2], Leon M. Tolbert[2]
[1]Smith College, United States; [2]University of Tennessee, United States

9:30 a.m. – 9:50 a.m.

T11.4 **Optimal Sizing of a PV and Battery Storage System Using a Detailed Model of the Microgrid for Stand-Alone Applications**
German Nahuel Bogado, Francisco Paz, Ignacio Galiano Zurbriggen, Martin Ordonez
University of British Columbia, Canada

9:50 a.m. – 10:10 a.m.

T11.5 **Dispatchable Virtual Oscillator Control for Decentralized Inverter-Dominated Power Systems: Analysis and Experiments**
Gab-Su Seo[2], Marcello Colombino[2], Irina Subotic[1], Brian Johnson[3], Dominic Groß[1], Florian Dörfler[1]
[1]ETH Zurich, Switzerland; [2]National Renewable Energy Laboratory, United States; [3]University of Washington, United States

8:30 a.m. – 10:10 a.m.

T12: Rectifiers for EV Charging

ROOM 213D

Transportation Power Electronics

CHAIRS:

Arun K. Kadavelugu, *ABB Corporate Research*

Yingying Kuai, *Caterpillar Inc.*

8:30 a.m. – 8:50 a.m.

T12.1 **A Soft Switched Boost Cascaded-by-Buck Power Factor Correction Converter for on-Board Battery Charger Application**
Jaya Sai Praneeth A.V., Sheldon S Williamson
University of Ontario Institute of Technology, Canada

8:50 a.m. – 9:10 a.m.

T12.2 **A Direct Switch-Mode Three-Phase AC to DC Rectifier with High-Frequency Isolation for Fast EV Battery Chargers**
Erick Pool-Mazun[2], Jose Sandoval[2], Prasad Enjeti[2], Ira Pitel[1]
[1]Magna Power Electronics, United States; [2]Texas A&M University, United States

9:10 a.m. – 9:30 a.m.

T12.3 **A 12.47 kV Medium Voltage Input 350 kW EV Fast Charger Using 10 kV SiC MOSFET**
Xinyu Liang, Srdjan Srdic, Jehyuk Won, Erick Aponte, Kristen Booth, Srdjan Lukic
North Carolina State University, United States

9:30 a.m. – 9:50 a.m.

T12.4 **One-Step-Ahead Adaptive Control Scheme for Active Rectifiers in Wild Frequency Applications**
Joseph Benzaquen, Fariba Fateh, Mohammad B. Shadmand, Behrooz Mirafzal
Kansas State University, United States

9:50 a.m. – 10:10 a.m.

T12.5 **An Interleaved 6-Level GaN Bidirectional Converter for Level II Electric Vehicle Charging**
Derek Chou, Kelly Fernandez, Robert Pilawa-Podgurski
University of California, Berkeley, United States

8:30 a.m. – 10:10 a.m.

T13: Inverter Modulation & Control Strategies

ROOM 303AB

Motor Drives and Inverters

CHAIRS:

Ali Bazzi, *University of Beirut/University of Connecticut*

Poria Fajri, *University of Nevada, Reno*

8:30 a.m. – 8:50 a.m.

T13.1 **Decoupled Direct Digital Control with D-Σ Process and Average Common-Mode Voltage Model for 3ϕ3W LCL Converters**
Tsai-Fu Wu, Yen-Hsiang Huang, Yun-Tsung Liu, Mitradatta Misra
National Tsing Hua University, Taiwan

8:50 a.m. – 9:10 a.m.

T13.2 **A Robust Feedback Repetitive Control for Inverters with LLCL Filter Connected to Weak Grid**
Yaoqin Jia, Wanrong Li
Xi'an Jiaotong University, China

9:10 a.m. – 9:30 a.m.

T13.3 **Hierarchical Model Predictive Control for Cascaded Multilevel Inverters**
Mitchell Easley[1], Sarthak Jain[2], Mohammad B. Shadmand[1], Fariba Fateh[1], Behrooz Mirafzal[1]
[1]Kansas State University, United States; [2]Renesas Electronics, United States

9:30 a.m. – 9:50 a.m.

T13.4 **A Novel Modulation Method for Half-Bridge Based Modular Multilevel Converters Under Submodule Failure with Reduced Switching Frequency**
Seok-Min Kim[1], June-Seok Lee[2], Kyo-Beum Lee[1]
[1]Ajou University, Korea; [2]Korea Railroad Research Institute, Korea

9:50 a.m. – 10:10 a.m.

T13.5 **Assessment of a NPC Frequency Inverter with Low Switching Frequency Modulation for a High Speed Rating Operation of an Induction Motor**
Marcos Paulo Brito Gomes[2], Alex-Sander Amável Luiz[1], Marcelo Martins Stopa[1], Gabriel Vilkn Ramos[1], Igor Amariz Pires[3]
[1]Centro Federal de Educação Tecnológica de Minas Gerais, Brazil; [2]Federal University of Minas Gerais, Brazil; [3]Universidade Federal de Minas Gerais, Brazil

8:30 a.m. – 10:10 a.m.

T14: Integration & EMI Considerations of Power Converters

ROOM 303CD

Power Electronics Integration and Manufacturing

CHAIRS:

Yu Du, *ABB Inc.*

Fred Weber, *FTW, LLC*

8:30 a.m. – 8:50 a.m.

T14.1 **2-D Magnetoresistive Point Field Detector-Based Current Sensing for High-Density Power Modules**
Muhammad Alvi, Minhao Sheng, Robert Lorenz
University of Wisconsin-Madison, United States

8:50 a.m. – 9:10 a.m.

T14.2 **Design of Active EMI Filters with the Integrated Passive Component**
Liyu Dai, Wenjie Chen, Yang Yang, Rui Wang, Xu Yang
Xi'an Jiaotong University, China

9:10 a.m. – 9:30 a.m.

T14.3 **Failure Protection for Controller Area Network Against EMI Emitted by Buck Converter**
Ryo Shirai, Toshihisa Shimizu
Tokyo Metropolitan University, Japan

9:30 a.m. – 9:50 a.m.

T14.4 **Passive Integrations for Γ-Z Source & Dab DC-AC Bidirectional Converter**
Jie Xiong[3], Jianhong Jia[1], Cheng Deng[2]
[1]Hunan Railway Professional Technology College, China; [2]Xiangtan University, China; [3]Zhejiang University, China

9:50 a.m. – 10:10 a.m.

T14.5 **Parasitic Inductance Modeling and Reduction for a Wire Bonded Half Bridge SiC MOSFET Multichip Power Module**
Boyi Zhang, Shuo Wang
University of Florida, United States

8:30 a.m. – 10:10 a.m.

T15: Optimization of Wireless Power Transfer Systems

ROOM 304AB

Wireless Power Transfer

CHAIRS:

Khurram Afridi, *Cornell University*

Raghav Khanna, *University of Toledo*

8:30 a.m. – 8:50 a.m.

T15.1 **Soft Switching Realization of LCCL-LC Resonant Converter for Wireless Power Transfer Application**
Junjie Feng, Qiang Li, Fred C. Lee
Virginia Polytechnic Institute and State University, United States

8:50 a.m. – 9:10 a.m.

T15.2 **Rectifier Topology Comparison in 6.78 MHz Highly Resonant Wireless Power Systems**
Yuanzhe Zhang, Michael de Rooij
Efficient Power Conversion Corporation, United States

9:10 a.m. – 9:30 a.m.

T15.3 **Voltage Slope-Sensing Based Zero Voltage Switching Detection for 6.78 MHz Wireless Power Transfer Application**
Ling Jiang, Daniel J. Costinett
University of Tennessee, United States

9:30 a.m. – 9:50 a.m.

T15.4 **A Multi-MHz Wireless Power Transfer System with Mains Power Factor Correction Circuitry on the Receiver**
Juan Arteaga, Samer Aldhaher, David Yates, Paul Mitcheson
Imperial College London, United Kingdom

9:50 a.m. – 10:10 a.m.

T15.5 **Power Loss Analysis of a Back-to-Back Switching Single-Inductor Multiple-Output Inverter**
Weijian Jin, Albert Ting Leung Lee, Siew-Chong Tan, Ron Shu Yuen Hui
University of Hong Kong, Hong Kong

8:30 a.m. – 10:10 a.m.

T16: Medical/Computing/Lighting Applications

ROOM 304CD

Power Electronics Applications

CHAIRS:

Ed Massey, *Methode*

Indumini Ranmuthu, *TI*

8:30 a.m. – 8:50 a.m.

T16.1 **Capacitive Energy Storage for Magnetic Resonant Imaging Gradient Driver**
Yash Veer Singh, Juan A Sabate, Ruxi Wang
GE Global Research, United States

8:50 a.m. – 9:10 a.m.

T16.2 **Signal and Pattern Generation for Muscle Manipulation in Medical Applications**
Hagit Perets Habany, Michael Evzelman, Mor Mordechai Peretz
Ben-Gurion University of the Negev, Israel

9:10 a.m. – 9:30 a.m.

T16.3 **WBG Semiconductor and Capacitor Technology Evaluation for Pulsed Electroporation Applications**
Hector Sarnago, Jose Miguel Burdío, Oscar Lucia
Universidad de Zaragoza, Spain

9:30 a.m. – 9:50 a.m.

T16.4 **Active Harmonic Filtering with a Low Switching Frequency Inverter**
Meng-Jiang Tsai, Yu-Fan Liou, Po-Tai Cheng
National Tsing Hua University, Taiwan

9:50 a.m. – 10:10 a.m.

T16.5 **A New Adaptive Drive Voltage Approach for LED Driver**
Yang Hu, Lei Jiang, Wei Wen, Wanghui Yan, Ran Ding
Opple Lighting Co., Ltd., China

2:00 p.m. – 5:30 p.m.

T17: Single-Phase AC-DC Converters

ROOM 211AB

AC-DC Converters

CHAIRS:

Qiang Li, *Virginia Tech*

Gerry Moschopoulos, *Western University*

2:00 p.m. – 2:20 p.m.

T17.1 **Inductor Design and ZVS Control for a GaN-Based High Efficiency CRM Totem-Pole PFC Converter**
Jingjing Sun, Xingxuan Huang, Nathan Strain, Daniel J. Costinett, Leon M. Tolbert
University of Tennessee, United States

2:20 p.m. – 2:40 p.m.

T17.2 **An Accurate Variable on-Time Control for 400Hz CRM Boost PFC Converters**
Yu Wu, Xiaoyong Ren, Kunqi Li, Zhiliang Zhang, Qianhong Chen
Nanjing University of Aeronautics and Astronautics, China

2:40 p.m. – 3:00 p.m.

T17.3 **Fixed-Frequency Modulator for PFC with Power Semiconductor Filter to Mitigate Oscillation in the Input Current**
Kun Zhang[1], Akhil Relekar[1], John Wing-To Fan[1], Jeff Po-Wa Chow[1], Wan-Tim Chan[1], Chung-Pui Tung[1], Ray Ho[2], Henry Shu-Hung Chung[1]
[1]City University of Hong Kong, Hong Kong; [2]Mosway Semiconductor Limited, Hong Kong

3:00 p.m. – 3:20 p.m.

T17.4 **A Hybrid Digital Control System for LED Grow Lights**
Rahil Samani, Milad Zareie, Dawood Shekari, Liam Wrubleski, Majid Pahlevani
University of Calgary, Canada

3:20 p.m. – 3:40 p.m.

T17.5 **Single-Stage LLC Charger with PFC Functionality and Wide Input Voltage Range**
Martin Wattenberg[1], Ulf Schwalbe[1], Martin Pfost[2]
[1]Reutlingen University, Germany; [2]Technical University of Dortmund, Germany

3:40 p.m. – 4:10 p.m.

Break

4:10 p.m. – 4:30 p.m.

T17.6 **A New Single-Stage Bridgeless Boost Half-Bridge AC/DC Converter with Semi-Active-Rectifier**
Adhistira Madhyasta Naradhipa, Suhan Kang, Byeongwoo Kim, Sewan Choi
Seoul National University of Science and Technology, Korea

4:30 p.m. – 4:50 p.m.

T17.7 **A New Control Method for a Novel Isolated, Bridgeless Single-Stage AC/DC Converter Used in Industrial Battery Chargers**
Iman Askarian[2], Nick Dohmeier[1], Chris Botting[1], Majid Pahlevani[2], Andy Knight[2]
[1]Delta-Q Technologies, Canada; [2]University of Calgary, Canada

4:50 p.m. – 5:10 p.m.

T17.8 **A High-Power-Density Electrolytic-Free Offline LED Driver Utilizing a Merged Energy Buffer Architecture**
Mausamjeet Khatua, Danish Shahzad, Saad Pervaiz, Khurram Afridi
University of Colorado Boulder, United States

5:10 p.m. – 5:30 p.m.

T17.9 **A Wide Input Voltage Range PFC Converter with High-Efficiency**
Hamed Valipour, Mohammad Mahdavi, Martin Ordonez
University of British Columbia, Canada

2:00 p.m. – 5:30 p.m.

T18: Resonant DC-DC Converters

ROOM 212AB

DC-DC Converters

CHAIRS:

Cahit Gezgin, *Infineon*

Abey K. Mathew, *IBM*

2:00 p.m. – 2:20 p.m.

T18.1 **Effects of Secondary Leakage Inductance on the LLC Resonant Converter—Part I: Transformer Voltage Gain and Efficiency**
Mostafa Noah[1], Tomohide Shirakawa[2], Kazuhiro Umetani[2], Jun Imaoka[1], Masayoshi Yamamoto[1], Eiji Hiraki[2]
[1]Nagoya University, Japan; [2]Okayama University, Japan

2:20 p.m. – 2:40 p.m.

T18.2 **Innovative Control Method for a Dual Independent Output LLC Resonant Converter**
Alberto Bianco[2], Francesco Ciappa[2], Marcello Chiaberge[1], Giuseppe Scappatura[2]
[1]Politecnico di Torino, Italy; [2]STMicroelectronics, Italy

2:40 p.m. – 3:00 p.m.

T18.3 **An Improved LLC Resonant Converter with Phase-Shift Controlled Dynamic Series-Parallel Reconfiguration-Windings for Hold-Up Applications**
Xinxi Tang[1], Yan Xing[1], Hongfei Wu[1], Kai Sun[3], Xudong Ma[2]
[1]Nanjing University of Aeronautics and Astronautics, China; [2]Southeast University, China; [3]Tsinghua University, China

3:00 p.m. – 3:20 p.m.

T18.4 **An Investigation on Fully Zero-Voltage-Switching Condition for High-Frequency GaN Based LLC Converter in Solid-State-Transformer Application**
Hao Wen, Jinwu Gong, Chih-Shen Yeh, Yaofei Han, Jih-Sheng Jason Lai
Virginia Polytechnic Institute and State University, United States

3:20 p.m. – 3:40 p.m.

T18.5 **Topology Evaluation and Comparison for Isolated Multilevel DC/DC Converter for Power Cell in Solid State Transformer**
Yang Jiao, Milan Jovanović
Delta Electronics Ltd., United States

3:40 p.m. – 4:10 p.m.

Break

4:10 p.m. – 4:30 p.m.

T18.6 **A Low Profile Stacked Transformer for High-Efficiency High-Output-Current 380 V/12 V LLC Resonant Converters**
Jahangir Afsharian[2], Bing Gong[1], Ning Zhu[1], Dewei Xu[2], Zhihua Yang[1]
[1]Murata Power Solution, Canada; [2]Ryerson University, Canada

4:30 p.m. – 4:50 p.m.

T18.7 **Fixed Frequency Phase Shift Modulated LLC Resonant Converter Adapted to Ultra Wide Output Voltage Range**
Qi Cao, Zhiqing Li, Bo Xue, Haoyu Wang
ShanghaiTech University, China

4:50 p.m. – 5:10 p.m.

T18.8 **Suppressing Methods of Common-Mode Noise in LLC Resonant DC-DC Converters**
Yue Han, Jinxu Yang, Xinke Wu
Zhejiang University, China

5:10 p.m. – 5:30 p.m.

T18.9 **Analysis of the Zero-Voltage Switching Condition in LLC Series Resonant Converter with Secondary Parasitic Capacitors**
Cheng-Wei Chen, Xiaonan Zhao, Chih-Shen Yeh, Jih-Sheng Jason Lai
Virginia Polytechnic Institute and State University, United States

2:00 p.m. – 5:30 p.m.

T19: Wireless Power Transfer Applications

ROOM 213C

Wireless Power Transfer

CHAIRS:

Faisal Khan, *University of Missouri at Kansas City*

Sheldon Williamson, *University of Ontario Institute of Technology*

2:00 p.m. – 2:20 p.m.

T19.1 **Design and Evaluation of a Multilevel Switched Capacitor Rectifier for Wireless Fast Charging**
Chongwen Zhao[2], Spencer Cochran[2], Daniel J. Costinett[2], Songnan Yang[1]
[1]FutureWei Technologies, Inc., United States; [2]University of Tennessee, United States

2:20 p.m. – 2:40 p.m.

T19.2 **1.2-mm Thin and Compact Direct AC-DC Converter in Wireless Power Receiver Suitable for Wearable Devices**
Atsushi Muramatsu, Hiroyuki Nakamoto
Fujitsu Laboratories Ltd., Japan

2:40 p.m. – 3:00 p.m.

T19.3 **Design of an RF Power Generator for Microwave Power Transmission System**
Qi Hui, Ke Jin, Xirui Zhu
Nanjing University of Aeronautics and Astronautics, China

3:00 p.m. – 3:20 p.m.

T19.4 **Dual-Band Multi-Receiver Wireless Power Transfer: Architecture, Topology, and Control**
Ming Liu, Minjie Chen
Princeton University, United States

3:20 p.m. – 3:40 p.m.

T19.5 **Design of Near Field Shielding Strategy by Theoretical Calculation for a Multi-Load WPT System**
Tianluan Xiao, Wenjie Chen, Yang Yang, Liyu Dai, Rui Wang, Xu Yang
Xi'an Jiaotong University, China

3:40 p.m. – 4:10 p.m.

Break

4:10 p.m. – 4:30 p.m.

T19.6 **Design and Control of a Bidirectional Wireless Charging System Using GaN Devices**
Haimeng Wu[1], Bowen Gu[1], Xiang Wang[1], Volker Pickert[1], Bing Ji[2]
[1]Newcastle University, United Kingdom;
[2]University of Leicester, United Kingdom

4:30 p.m. – 4:50 p.m.

T19.7 **Bridgeless Rectifier Control of Wireless Power Transfer to Improve Efficiency**
Won-Jin Son, Jae Han Lee, Sangjoon Ann, Jongeun Byun, Byoung Kuk Lee
Sungkyunkwan University, Korea

4:50 p.m. – 5:10 p.m.

T19.8 **Small-Signal Phasor Modeling of an Underwater IPT System in Constant Current Distribution**
Anindya Chitta Bagchi, Hongjie Wang, Tarak Saha, Regan Zane
Utah State University, United States

5:10 p.m. – 5:30 p.m.

T19.9 **Single-Inductor Multiple-Output (SIMO) Buck Hybrid Converter with Simultaneous AC and DC Outputs for Multi-Coil Wireless Power Transfer Applications**
Albert Ting Leung Lee, Weijian Jin, Siew-Chong Tan, Ron Shu Yuen Hui
University of Hong Kong, Hong Kong

2:00 p.m. – 5:30 p.m.

T20: Control Strategies for Inverters and Motor Drives

ROOM 213D

Control

CHAIRS:

Jaber Abu Qahouq, *The University of Alabama*

Yusi Liu, *ON Semiconductor*

2:00 p.m. – 2:20 p.m.

T20.1 **Current Control Using Pulsed Current Sampling Considering Sampling Points and Sensor Positions for Single-Phase Inverter**
Kensuke Suzuki, Keiji Wada
Tokyo Metropolitan University, Japan

2:20 p.m. – 2:40 p.m.

T20.2 **Memory Space Adjustable Repetitive Controller Design for Isolated Cuk Inverter**
Byeongcheol Han[3], Changkyu Bai[2], Jih-Sheng Jason Lai[3], Minsung Kim[1]
[1]Dongguk University, Korea; [2]Pohang University of Science and Technology, Korea; [3]Virginia Polytechnic Institute and State University, United States

2:40 p.m. – 3:00 p.m.

T20.3 **Finite Control Set Model Predictive Control Strategy of Line-Voltage Cascaded Inverter with Low-Value Inductor**
Huan Yao[2], Tingna Shi[3], Xin Gu[1], Zhiqiang Wang[1], Guozheng Zhang[1]
[1]Tianjin Polytechnic University, China; [2]Tianjin University, China; [3]Zhejiang University, China

3:00 p.m. – 3:20 p.m.

T20.4 **A Novel 2N+1 Carrier-Based Pulse Width Modulation Scheme for Modular Multilevel Converters with Reduced Control Complexity**
Deepak Ronanki, Sheldon S Williamson
University of Ontario Institute of Technology, Canada

3:20 p.m. – 3:40 p.m.

T20.5 **Variable Switching Frequency Strategy Based on Circulating Current Analysis in Paralleled Inverters with Interleaved PWM**
Qiao Li[1], Dong Jiang[1], Zewei Shen[1], Yechi Zhang[1], Xuan Zhao[1], Yingtao Ma[2]
[1]Huazhong University of Science and Technology, China;
[2]State Key Laboratory for Traction and Control System of EMU and Locomotive, China

3:40 p.m. – 4:10 p.m.

Break

4:10 p.m. – 4:30 p.m.

T20.6 **Development of a Controller Based on Compensation of Fourier Series Coefficients of Voltage Error for Stand-Alone Inverters**
Bunyamin Tamyurek[1], Celil Yagiz[2]
[1]Eskisehir Osmangazi University, Turkey; [2]KOLT Inc., Turkey

4:30 p.m. – 4:50 p.m.

T20.7 **Novel Power Control of Voltage-Controlled Inverters for Grid Inertia Support**
Xiangjun Quan Quan, Xin Zhao, Liqi Zhang, Rong Xu, Yang Lei, Alex Q. Huang
University of Texas at Austin, United States

4:50 p.m. – 5:10 p.m.

T20.8 **Impact of Common-Mode Circuit on Variable Switching Frequency PWM Strategy in Voltage Source Inverters**
Qiao Li, Dong Jiang, Jianan Chen, Yechi Zhang
Huazhong University of Science and Technology, China

5:10 p.m. – 5:30 p.m.

T20.9 **Effect of Current Measurement Timing and Antialiasing Filter in a Single-Phase Inverter**
Juhamatti Korhonen, Jari Honkanen, Juuso Rautio, Pertti Silventoinen
Lappeenranta University of Technology, Finland

2:00 p.m. – 5:30 p.m.

T21: Driving WBG Devices

ROOM 303AB

Devices and Components

CHAIRS:

Alireza Dayerizadeh, *North Carolina State University*

Dong Dong, *Virginia Tech*

2:00 p.m. – 2:20 p.m.

T21.1 **Influence of the Threshold Voltage Hysteresis and the Drain Induced Barrier Lowering on the Dynamic Transfer Characteristic of SiC Power MOSFETs**
Patrick Hofstetter, Robert Wolfgang Maier, Mark-Matthias Bakran
University of Bayreuth, Germany

2:20 p.m. – 2:40 p.m.

T21.2 **Impact of Threshold Voltage Instability on Static and Switching Performance of GaN Devices with p-GaN Gate**
Fei Yang, Chi Xu, Bilal Akin
University of Texas at Dallas, United States

2:40 p.m. – 3:00 p.m.

T21.3 **Screen-Returned PCB Rogowski Coil for the Switch Current Measurement of SiC Devices**
Lei Ming[1], Zhen Xin[1], Changqing Yin[1], Poh Chiang Loh[1], Yang Liu[2]
[1]Chinese University of Hong Kong, Hong Kong; [2]Huazhong University of Science and Technology, China

3:00 p.m. – 3:20 p.m.

T21.4 **In Depth Analysis of Driving Loss and Driving Power Supply Structure for SiC MOSFETs**
Xuning Zhang, Gin Sheh, Inhwan Ji, Sujit Banerjee
Monolith Semiconductor Inc., United States

3:20 p.m. – 3:40 p.m.

T21.5 **Current Source Gate Drive to Reduce Switching Loss for SiC MOSFETs**
Handong Gui[2], Zheyu Zhang[2], Ruirui Chen[2], Jiahao Niu[2], Leon M. Tolbert[2], Fred Wang[2], Benjamin J. Blalock[2], Daniel J. Costinett[2], Benjamin B. Choi[1]
[1]NASA Glenn Research Center, United States; [2]University of Tennessee, United States

3:40 p.m. – 4:10 p.m.

Break

4:10 p.m. – 4:30 p.m.

T21.6 **Transient-Immune GaN Gate Driver and Power Layout**
Pramod Kumar Prasobhu[2], Felix Hoffmann[2], Marco Liserre[1]
[1]Christian-Albrechts-Universität zu Kiel, Germany; [2]Kiel University, Germany

4:30 p.m. – 4:50 p.m.

T21.7 **Design of Active SiC MOSFET Gate Driver for Crosstalk Suppression Considering Impedance Coordination Between Gate Loop and Power Loop**
Zhebie Lu[2], Chengmin Li[2], Han Wu[2], Wuhua Li[2], Xiangning He[2], Shan Li[1]
[1]Shanghai Marine Equipment Research Institute, China; [2]Zhejiang University, China

4:50 p.m. – 5:10 p.m.

T21.8 **Current Source Gate Driver for Series Connected Silicon-Carbide (SiC) MOSFETs**
Chunhui Liu, Qin Lei
Arizona State University, United States

5:10 p.m. – 5:30 p.m.

T21.9 **Empirical Circuit Model for Output Capacitance Losses in Silicon Carbide Power Devices**
Zikang Tong, Sanghyeon Park, Juan Rivas-Davila
Stanford University, United States

2:00 p.m. – 5:30 p.m.

T22: Drives & Inverters: Parameter Identification, Measurement & Diagnostics

ROOM 303CD

Motor Drives and Inverters

CHAIRS:

Mehdi Farasat, *Louisiana State University*

Mithat Kisacikoglu, *University of Alabama*

2:00 p.m. – 2:20 p.m.

T22.1 **GaN PCB Integrated Sensing System for Switch and Capacitor Currents**
Minhao Sheng, Muhammad Alvi, Robert Lorenz
University of Wisconsin-Madison, United States

2:20 p.m. – 2:40 p.m.

T22.2 **An Integrated and Galvanically Isolated DC-to-15.3 MHz Hybrid Current Sensor**
Tobias Funk[2], Johannes Groeger[2], Bernhard Wicht[1]
[1]Leibniz University Hannover, Germany;
[2]Reutlingen University, Germany

2:40 p.m. – 3:00 p.m.

T22.3 **Initial Rotor Position Estimation for Brushless Synchronous Starter/Generators**
Shuai Mao[2], Weiguo Liu[2], Jichang Peng[2], Ningfei Jiao[2], Yu Jiang[1]
[1]AVIC Shaanxi Aero Electric Co., Ltd., China;
[2]Northwestern Polytechnical University, China

3:00 p.m. – 3:20 p.m.

T22.4 **On-Line Monitoring of Stator Inter-Turn Failures in DTC Driven Asynchronous Motors Using Mathematical Morphological Gradient**
Hassan Eldeeb[1], Alberto Berzoy[2], Ahmed Saad[1], Osama Mohammed[1]
[1]Florida International University, United States;
[2]Sonnen Batterie Inc., United States

3:20 p.m. – 3:40 p.m.

T22.5 **High Frequency Voltage Injection Based Fault Detection of Rotating Rectifier for Three-Stage Synchronous Starter/Generator in the Stationary State**
Chenghao Sun[2], Weiguo Liu[2], Yujie Zhu[2], Shuai Mao[2], Tao Meng[2], Ji Pang[2], Dan Li[1]
[1]AVIC Shaanxi Aero Electric Co., Ltd., China;
[2]Northwestern Polytechnical University, China

3:40 p.m. – 4:10 p.m.

Break

4:10 p.m. – 4:30 p.m.

T22.6 **Phase Current Reconstruction Based on Rogowski Coils Integrated on Gate Driver of SiC MOSFET Half-Bridge Module for Continuous and Discontinuous PWM Inverter Applications**
Slavko Mocevic[2], Jun Wang[2], Rolando Burgos[2], Dushan Boroyevich[2], Marko Jaksic[1], Mehrdad Teimor[1], Brian Peaslee[1]
[1]General Motors, United States; [2]Virginia Polytechnic Institute and State University, United States

4:30 p.m. – 4:50 p.m.

T22.7 **Determination of Cable Characteristics and Adjustment of PWM Pulse Pattern to Minimize AC Motor Terminal Over-Voltage**
Nandini Ganesan, Rangarajan Tallam
Rockwell Automation Inc., United States

4:50 p.m. – 5:10 p.m.

T22.8 **Parameter Estimation of Permanent Magnet Synchronous Machines Based on a New Model Considering Discretization Effects of Digital Controllers**
Gorkem Secer[2], Goksel Kizir[1], Murat Sahin[2]
[1]Gazi University, Turkey; [2]ROKETSAN Missiles Inc., Turkey

5:10 p.m. – 5:30 p.m.

T22.9 **Open-Phase Fault Control in Open-Winding PMSM System with Common DC Bus**
Chenhui Ruan, Wei Hu, Heng Nian, Dan Sun
Zhejiang University, China

2:00 p.m. – 5:30 p.m.

T23: Diagnostic and Fault-Tolerant Control of Renewable Energy Systems

ROOM 304AB

Renewable Energy Systems

CHAIRS:

Minjie Chen, *Princeton University*

Fei Lu, *Drexel University*

2:00 p.m. – 2:20 p.m.

T23.1 **Fault Remediation for Distributed Photovoltaic (PV) System**
Palak Jain[1], Jai Prakash Singh[2], Sanjib Kumar Panda[1]
[1]National University of Singapore, Singapore;
[2]Solar Energy Research Institute of Singapore, Singapore

2:20 p.m. – 2:40 p.m.

T23.2 **Threshold Point Calculation Method Using Instantaneous Phase Current for Switch Fault Diagnosis of AC-DC Converters in Hybrid Grid Systems**
Geun Wan Koo, Byoung Kuk Lee, Dong-Myoung Joo
Sungkyunkwan University, Korea

2:40 p.m. – 3:00 p.m.

T23.3 **FRT Capability of Three-Phase Grid-Tied Converter with Minimized Inductor**
Satoshi Nagai, Jun-Ichi Itoh
Nagaoka University of Technology, Japan

3:00 p.m. – 3:20 p.m.

T23.4 **Photovoltaic Panel Health Diagnostic System for Solar Power Plants**
Martin Garaj[2], Kelvin Yiwen Hong[2], Henry Shu-Hung Chung[2], Jianfeng Zhou[2], Alan Wai-Lun Lo[1]
[1]Chu Hai College of Higher Education, Hong Kong;
[2]City University of Hong Kong, Hong Kong

3:20 p.m. – 3:40 p.m.

T23.5 **A Three-Phase Adaptive Active Damper for Improving the Stability of Grid-Connected Inverters Under Weak Grid**
Zhiheng Lin, Xinbo Ruan
Nanjing University of Aeronautics and Astronautics, China

3:40 p.m. – 4:10 p.m.

Break

4:10 p.m. – 4:30 p.m.

T23.6 **Experimental Assessment and Stability Analysis of a Discrete-Time Battery Model with Multiple Constant Phase Elements**
Chun-Sing Cheng, Henry Shu-Hung Chung, Wing-Hong Lau, Kelvin Yi-Wen Hong
City University of Hong Kong, Hong Kong

4:30 p.m. – 4:50 p.m.

T23.7 **Region Based Stability Analysis of Active Dampers in AC Microgrids with Multiple Parallel Interface Inverters**
Yan Guo[3], Laijun Chen[3], Xiaonan Lu[2], Jianhui Wang[1], Tianwen Zheng[3], Shengwei Mei[3]
[1]Southern Methodist University, United States; [2]Temple University, United States; [3]Tsinghua University, China

4:50 p.m. – 5:10 p.m.

T23.8 **Improved Operation of DFIG System Under Harmonically Distorted Grid Considering Inter-Harmonics**
Bo Pang, Heng Nian, Chao Wu
Zhejiang University, China

5:10 p.m. – 5:30 p.m.

T23.9 **Modified Adaptive Virtual Impedance Method to Compensate Mismatched Line Impedances in Microgrids**
Ronghui An, Zeng Liu, Jinjun Liu
Xi'an Jiaotong University, China

2:00 p.m. – 5:30 p.m.

T24: Transportation/Storage/Grid

ROOM 304CD

Power Electronics Applications

CHAIRS:

Petar Grbovic, *University of Innsbruck/Innsbruck Power Electronics Lab. (i-PEL)*

Tae H. Kim, *Futurewei (Huawei US R&D)*

2:00 p.m. – 2:20 p.m.

T24.1 **A Bidirectional Modular DC-AC Converter with High Frequency Isolation for Marine Application**
Aritra Basu, Gautam Poddar
Indian Institute of Technology Kharagpur, India

2:20 p.m. – 2:40 p.m.

T24.2 **A Comparative Study of Failure-Tolerant Three-Phase RTRUs for More Electric Aircrafts**
Akshay Singh, Ayan Mallik, Alireza Khaligh
University of Maryland, United States

2:40 p.m. – 3:00 p.m.

T24.3 **A DC-Link Capacitor Voltage Balancer Integrated Into LLC-Based Auxiliary Power Supply**
Yuxiang Shi, Yu Du, Zach Pan, Eddy Aeloiza, Arun K. Kadavelugu, Liming Liu
ABB Inc., United States

3:00 p.m. – 3:20 p.m.

T24.4 **Design Considerations for Turbo Rack with Smart Battery Backup System (BBS)**
Xiaoguo Liang[1], Edmund Song[2], Feng Jiang[2], Nishi Ahuja[2], Mohan Kumar[2]
[1]Intel Asia Pacific R&D Ltd., China; [2]Intel Corporation, United States; [2]Intel Corporation, China

3:20 p.m. – 3:40 p.m.

T24.5 **Bidirectional Coupled Inductor Based Hybrid Circuit Breaker Topologies for DC System Protection**
Anindya Ray[2], Kaushik Rajashekara[2], Satish Naik Banavath[1]
[1]Mahindra Electric Mobility Ltd, India; [2]University of Houston, United States

3:40 p.m. – 4:10 p.m.

Break

4:10 p.m. – 4:30 p.m.

T24.6 **Voltage Support Strategy of SNOP Under Fault Circumstance**
Yuze Li[1], Xuejun Pei[1], Yong Kang[1], Yi Lu[2], Feng Xu[2], Chaoliang Wang[2]
[1]Huazhong University of Science and Technology, China; [2]State Grid Zhejiang Electric Power Research Institute, China

4:30 p.m. – 4:50 p.m.

T24.7 **Non-Linear Droop Control of Parallel Split-Phase Inverters for Residential Nanogrids**
Alberto Berzoy[1], Andres Salazar[1], Farid Moghadam Khalizheli[1], Carlos Restrepo[1], Javad Mohammadpour Velni[2]
[1]Sonnen Batterie Inc., United States; [2]University of Georgia, United States

4:50 p.m. – 5:10 p.m.

T24.8 **Stability Analysis of a Medium Voltage Cascaded Converter System with Reduced DC-Link Capacitance**
Sayan Acharya, Anup Anurag, Subhashish Bhattacharya
North Carolina State University, United States

5:10 p.m. – 5:30 p.m.

T24.9 **Stability Analysis of Grid-Connected VSCs Based on Two-Port Network Theory**
Shih-Feng Chou, Xiongfei Wang, Frede Blaabjerg
Aalborg University, Denmark

EXHIBITOR SEMINARS

APEC 2019 Exhibitor Seminars will highlight new products or initiatives that companies in the power electronics industry are developing, along with allowing the opportunity for attendees to interact with other companies in the industry.

10:30 a.m. – 11:00 a.m.

Exhibitor Seminars – Session #5

Coilcraft, Inc.

ROOM 211AB

New Thinking Leads to Smaller Inductors and High Efficiency at High Frequency

PRESENTED BY: **Len Crane**

Selecting inductors and transformers for power converters often means invoking well-used rules of thumb. While these "rules" have been developed over many years and are based on real-life experience, it is necessary to move beyond them to truly optimize designs and achieve new size and performance targets. While it is usually assumed that inductor losses will increase at high switching frequency, for example, this presentation describes creative ways of viewing magnetic operation that can lead to surprising solutions with smaller passive components and higher efficiency.

Danfoss Silicon Power GmbH

ROOM 212AB

Next Gen Automotive Power Modules: DCM™ platform by Danfoss Silicon Power

PRESENTED BY: **Brian L. Rowden**

Danfoss has introduced the direct cooled molded (DCM) module technology for traction applications in hybrid electric and battery electric vehicles. The DCM™ technology platform is truly flexible in being optimized to utilize Si, SiC or Si/SiC hybrid semiconductor setups. It ensures versatility and flexibility by allowing the customers to utilize scalable drive train inverters design approach. Using the same package and footprint for different inverter power classes opens the possibility to have scaling effects with the supporting hardware for the OEM's. The presentation will demonstrate measurement results obtained from system level setups, it will also introduce performance results of SiC based power modules.

GMW Associates

ROOM 213C

Test Instrumentation for Electric Vehicle Battery and Charging Systems

PRESENTED BY: **Ian Walker**

For current control and metering, Fluxgate-based DC/AC Transducers offer current ranges to +/-10kA, better than +/-0.01% accuracy from dc to 2kHz, resolution of better than 4ppmrms broadband and +/-1ppm per year dc stability. Rogowski Coil Clip-Around Coils with matching Analog Integrator enable measurement of ac current in the frequency range of a few Hz to 50MHz and can be optimized for accuracy and resolution at a specific frequency; a Probe for 85kHz Inductive Power Transfer (IPT) measurements is available with +/-300A range, amplitude accuracy of +/-0.3% and phase shift of <+/-1 degree. For IPT magnetic field measurement and mapping a 15x15x15mm Three-Component Magnetic Field Probe with field ranges to +/-10mT, 10kHz to 200kHz bandwidth.

NH Research

ROOM 213D

Battery Emulation for Powertrain & DC Fast Charger Testing

PRESENTED BY: **Martin M Weiss**

There are new testing challenges for Battery Electric Vehicle's powertrain components and DC Fast Chargers that can be addressed with modern battery emulation solutions. BEV's vehicle propulsion components and the DC Fast Chargers (CCS1, CCS2, & CHAdeMO) are designed to operate at 400VDC or at a newer 800VDC level. NHR will present our modular 600VDC/1200VDC Dual-Range Battery Emulator which is ideally suited for testing of powertrain components, complete skateboards and electric fueling systems. We invite you to come see how Battery Emulation is the right approach for faster, scalable and more repeatable testing of new automotive power electronic components.

OPAL-RT TECHNOLOGIES

EXHIBIT HALL D SHOW FLOOR: THEATER 1

Real-Time Simulation: Helping the World Build Better Products

PRESENTED BY: **Martin Belanger**

For nearly 20 years, OPAL-RT has conducted extensive research and development in the field of power electronics, in order to deliver the fastest and most accurate real-time simulation. OPAL-RT platforms for testing and validation of electronic controls cover a wide range of applications, from renewable energy conversion to highly complex multi-modular converters (MMC) and the electric motors of tomorrow's transportation industry. By combining precise expertise, experience and mathematical innovation, OPAL-RT has succeeded in creating the market's fastest computing level for real-time simulation on FPGA for power electronics applications. Fast real-time simulation achieves more accurate results and increases HIL and RCP test coverage, and now pushes back the boundaries of what is achievable with PHIL applications.

Power Integrations

EXHIBIT HALL D SHOW FLOOR: THEATER 2

Death to Heatsinks

PRESENTED BY: **Doug Bailey**

Examine most consumer product power supplies and you will find at least one heatsink. Generally, they are made out of a piece of extruded or stamped copper or aluminum. The heatsink's job is to couple wasted energy into the ambient environment, where it can't do any harm. Think about the concept of "wasted energy". Who says it's waste? Who says that it's OK to dispose of it and why is it wasted in the first place? In an age where advanced materials and sophisticated controller techniques abound, isn't it time for a rethink? Consider instead that the existence of a heatsink in a product represents a quantum of failure: Failure of our society to efficiently manage our energy resources, failure of our designers to specify products that are compact, light and unobtrusive and a failure of project definition experts to leverage the technologies that are readily available. As an industry, we are continuously tempted to sacrifice energy, product utility and cost of ownership for unit cheapness, passing the electricity bills onto the end user and wasting resources. This presentation is an unabashedly partisan attack on the practice of heatsinking, along with a review of the materials and techniques that we can, as engineers, leverage now and in the future to make better products. Death to Heatsinks!!!

SEMIKRON, Inc.

ROOM 303AB

Hybrid SiC Modules Optimized for Converter and Inverter Operations

PRESENTED BY: **Kevork Haddad**

The presentation will provide background of adding SiC diodes in power modules. Hybrid modules are a viable approach for medium to high power applications. However, converter and rectifier operations require different chip optimization due to different duty cycles in two level topologies. This optimization is necessary from the cost point of view due to high material cost of SiC. The presentation will give an overview of the SKiM platform. Also, it will pinpoint how freewheeling diode are stressed during converter or inverter operations. It will also introduce two newly developed and qualified hybrid SKiM modules that addresses the above concerns. Further, a perfect IGBT-SiC diode pairing is achieved by replacing medium speed IGBTs with high speed chips. Performance of the new hybrid modules are compared to their Si based counterpart by way of examples and benefits are highlighted.

Typhoon HIL, Inc.

ROOM 303CD

Ultra-High Fidelity Real-Time Simulation for Power Electronics and Microgrids

PRESENTED BY: **Bozica Kovacevic**

Typhoon HIL Inc. is the market and technology leader in the rapidly-growing field of ultra-high-fidelity controller-Hardware-in-the-Loop (C-HIL) simulation for power electronics, microgrids, and distribution networks. We provide industry- proven, vertically integrated test solutions along with highest-quality customer support. The company was founded in 2008 and since then has been creating products distinguished by the ultimate ease of use, unrivaled performance, leading-edge technology, and affordability. We stand behind our seamlessly integrated technology stack, from Typhoon HIL's application specific processors and ultra-robust numerical solver all the way to the schematic editor and SCADA system. The complete technology stack that empowers our customers to continuously exceed their controller software quality, performance, and time-to-market goals.

11:15 a.m. – 11:45 a.m.

Exhibitor Seminars – Session #6

AC Power Corp (Preen)

ROOM 303AB

Factors in Selecting Programmable AC Power Sources

PRESENTED BY: **Brian Hsu**

Many industrial and commercial applications in factory, research labs, and military need AC power sources with programmable voltage and frequencies for accomplish the testing procedures or requirements. Therefore it is important to understand different types of power sources, advantages, and key parameters when doing the selection for the applications. The presentation will start with a brief history of the technology, then go into explaining the difference between various designs, their requirements as well as advantages/disadvantages. Illustrations will be provided.

Apex Microtechnology

EXHIBIT HALL D SHOW FLOOR: THEATER 2

Pushing the Limits of Analog Power

PRESENTED BY: **Jens Eltze**

Apex Microtechnology's Director of Strategic Marketing, Jens Eltze, will be discussing one of Apex's new Power Op Amps and how to properly protect the device. The PA164 is a high-density power amplifier IC that utilizes MOSFET technology and a proprietary silicon design to deliver new benchmarks in performance and thermal management. Keeping the PA164 protected at high currents and voltages is critical to device success. In this seminar, learn how fail safes such as temperature compensated current limit, over-current flags, and feedback loops are enlisted to ensure smooth amplifier operation.

Helix Semiconductors

EXHIBIT HALL D SHOW FLOOR: THEATER 1

Realizing a Transformerless Future

PRESENTED BY: **Bud Courville**

It's an all-too familiar sight in today's homes and businesses: a tangle of cords emerging from behind a console, desk or conference table, connected to several large, bulky power supplies. TVs, DVD players, set-top boxes, sound bars, digital media devices, monitors, printers, routers, laptops…the list of devices connected to these power supplies is seemingly endless. It doesn't have to be this way, according to fabless power semiconductor company Helix Semiconductors. Traditional power supplies are built around century-old methods. Transformers are the culprit here: they are big, cumbersome, heavy, inefficient, and inflexible, and they usually dictate the size and form factor of a power supply. Getting the maximum amount of power in the smallest space possible is the key to a new way of powering the world, and proprietary technology from Helix Semiconductors has accomplished exactly that. Come listen to our story and learn about how our MxC 200 and MxC 300 family of products enable a transformerless future.

Henkel Company

ROOM 211AB

The Influence of Aspects of Solder Paste Formulation and Soldering Process Factors on Voiding Under Large Qfn Devices

PRESENTED BY: **Dr. Neil Poole**

When QFN and other bottom-terminated devices are soldered using solder paste at atmospheric pressure, some voiding is always observed. The process of void formation during reflow is dynamic; voids, primarily formed from volatilized flux materials and soldering reaction products, grow, coalesce and then vent at the margins of the solder joint while the solder is molten. As flux materials are an underlying cause of void formation, then solder paste formulation has considerable potential to influence the degree of voiding finally observed. This paper summarizes some studies concerned with the influence of an aspect of solder paste formulation – solvent choice – in conjunction with some process factors on voiding under a large (12 mm x 12 mm) QFN device.

ITG Electronics Inc.

ROOM 212AB

Electrical Noise Suppression and Common Mode Choke

PRESENTED BY: **Rickey Cheang**

At higher frequencies the impedance of a CM choke becomes an important factor to effectively

Suppress EMI noise. This presentation will briefly discuss CM noise generators and how it can be suppressed by using a CM choke. In addition, we'll discuss impedance improvements by using different winding techniques and wire shapes that enhance the performance and efficiency of the CM choke.

PEM Ltd

ROOM 213C

Delay, Rise-Time and Slew Rate Using CWT HF Optimised Rogowski Current Sensors in Power Electronics

PRESENTED BY: **Dr. Chris Hewson**

PEM's CWT range of Rogowski current sensors have been used in power electronic applications for over 25 years. Improvements in bandwidth for the new CWTHF ranges of Rogowski current sensors from PEM Ltd have opened up new application areas including measurements in SiC semiconductors. Understanding the limitations of high frequency bandwidth and how this relates in practice to rise-time, slew rate and delay of these new faster probes is discussed and illustrated with practical measurement examples.

Plexim
ROOM 213D

Code Generation and Real-time Simulation with PLECS and the RT Box

PRESENTED BY: **Bryan Lieblick**

Powerful new tools such as automatic code generation and hardware-in-the-loop testing are key to accelerating the design, programming, and validation of embedded control systems. In this seminar we will transform a PLECS simulation model of a power stage and controller into a real-time test of an embedded control system. We will showcase how to generate control code for a TI C2000 microprocessor from PLECS, and then verify the deployed control code using the PLECS RT Box in a HIL test bed. We will benchmark offline and real-time simulations, demonstrating how embedded controls can quickly be developed and tested in real-time using the PLECS toolchain.

pSemi, A Murata Company
ROOM 303CD

Novel Two-stage Bucks Achieve Unprecedented Efficiency in Ultra-low Profile and Footprint for Powering DDR5 Memory, ASICs and FPGAs

PRESENTED BY: **Stephen Allen**

Based on a patented architecture originating from MIT, pSemi is releasing a new family of DC-DC buck converters featuring a unique two-stage architecture that dramatically reduces the dependency on inductors, improves conversion efficiency and transient performance, and yet reduces solution footprint and profile. Targeting applications such as DDR5 memory, ASICs and FPGAs, the products are being released as both discrete component form, and as fully integrated modules. The latter benefit from the dramatic reduction in inductor size, allowing the use of advanced 3D semiconductor packaging technologies to achieve the world's smallest and most efficient fully integrated products on the market.

12:00 a.m. – 12:30 a.m.

Exhibitor Seminars – Session #7

Bose Research, Ltd
ROOM 211AB

Simplifying your Power Supply Designs, including EMI & Safety

Changsung Corporation
ROOM 212AB

Hybrid Magnetics

HBM Test and Measurement
ROOM 213C

Accelerate Motor Testing and Development Up to 100X

PRESENTED BY: **Mike Hoyer**

Every lab has unique interests to characterize, test and validate electric motors and drives using multiple pieces of measurement equipment from different suppliers. While these systems work, they often have high levels of complexity and operate much slower than an optimized system. This presentation proposes a solution specifically designed for motor and drive testing, consolidating many systems into one which allows rapid efficiency motor mapping and custom advanced real-time analysis significantly boosting productivity, capability and research and development by many days.

Instek America
ROOM 213D

Instek Value Proposition and Power Supply Testing Solution

Rohde & Schwarz
EXHIBIT HALL D SHOW FLOOR: THEATER 1

Oscilloscopes: An All-in-One Solution for Power Electronics Design – From Switching and Frequency Response Analysis to EMI Debugging

PRESENTED BY: **Mike Schnecker**

Oscilloscopes are the work horse for power electronics engineers. With frequency response analysis functionality and fast and convenient FFT capabilities available, they become a multi-purpose instrument for power electronics engineers. This talk covers key topics of interest for power electronics engineers: Bode plot functionality, switching analysis and EMI debugging.

Sino Nitride Semiconductor

ROOM 303AB

Advanced Manufacturing of GaN for Power Devices

PRESENTED BY: **Joe Lu**

Sino Nitride Semiconductor (SNS) was founded in 2009 as a GaN materials and service company. By introducing two new technologies, the laser lift-off and wet aching, high quality 2-inch bulk GaN wafer with dislocation density of 5×105 cm-2 can be achieved by vertical HVPE epitaxy. The HVPE batch reactor was designed to produce 2/4/6 inch GaN substrates at high throughput and low particulates. The deposition rate can be controlled from 2 to 100μm/hr. The quality of the GaN reveals the FWHM of 39.9 arcsec and 47.5 arcsec at (002) and (102) rocking curves respectively, indicating their high degree of crystalline stoichiometry. In addition, SNS launched 4-inch free-standing GaN substrates with dislocation density below 5×106cm-2 in 2018. HEMT devices have been built to verify the material integrity in handling the high power environment.

Speedgoat Inc.

ROOM 303CD

HIL Testing and Controls for Power Electronics Made Easy with Speedgoat Real-Time Solutions

PRESENTED BY: **Carlos Villegas** and **Tony Lennon**

Simulink Real-Time and HDL Coder, together with Speedgoat real-time systems, create a complete and seamless integrated real-time software and hardware environment for rapid control prototyping (RCP) and hardware-in-the-loop (HIL) simulation. Simulink Real-Time provides a high-performance host-target prototyping environment that enables you to connect your Simulink/Simscape models to physical systems either running C code on a CPU and/or HDL code on an FPGA. Speedgoat offers a wide band of optimized hardware sufficiently equipped with high speed analog and digital inputs and outputs. Verifying and testing the control hardware with its embedded software against a virtual prototype of the controlled system using deterministic and equivalent real-time simulation is a proven step before proceeding to prototype hardware testing. In HIL testing, power electronics, power stages, sources, loads, and even a grid network are simulated in system-level models running on dedicated real-time test systems. The system lets you perform initial testing of embedded software without risking damage to hardware prototypes and develop a high degree of confidence that your software will perform its intended functions. Advances are being made to real-time test hardware through the incorporation of FPGAs, for high speed I/O and for running the simulation, the latter presenting a new challenge of programming over the more common use of C code on a microprocessor.a

West Coast Magnetics

EXHIBIT HALL D SHOW FLOOR: THEATER 2

Challenges of Magnetic Component Core and Copper Loss Measurement

PRESENTED BY: **Weyman Lundquist**

Isolation of magnetic core and winding loss in a transformer or inductor from small signal measurements can prove a challenging task. The device under test must be evaluated before performing a test, to discern if it is in a range where it can be accurately measured, or if simulation is a better choice for estimating loss. If a small signal measurement is chosen to estimate loss, the results must be interpreted carefully. In this talk, we present measurement ranges in which winding and core loss can be extracted from a small signal impedance analyzer measurement, and a method for doing so when extraction is feasible.

INDUSTRY SESSIONS

At APEC 2019, the Industry Sessions track continues to expand. This track runs in parallel with the traditional Technical Sessions Track Speakers are invited to make a presentation only, without submitting a formal manuscript for the APEC Proceedings. This allows APEC to present information on current topics in power electronics from sources that would not otherwise be present at an industry conference. While many of these sessions are technical in nature, some also target business-oriented people such as purchasing agents, electronic system designers, regulatory engineers, and other people who support the power electronics industry. Presentations will be available through the APEC mobile app.

8:30 a.m. – 11:25 a.m.

IS16: Production Use Cases of Wide Band Gap Semiconductors

ROOM 209AB

CHAIRS:

Tim McDonald, *Infineon*

Primit Parikh, *Transphorm*

8:30 a.m. – 8:55 a.m.

IS16.1 **How SiC MOSFETs Enhance Efficiency, Reliability, and Performance of Electric Vehicles**
Jeffrey Fedison
EC Power Platform, United States

8:55 a.m. – 9:20 a.m.

IS16.2 **Silicon Carbide Inverter Technology Development – A Success Story**
Brij Singh
John Deere, United States

9:20 a.m. – 9:45 a.m.

IS16.3 **GaN ICs Enabling Next-Gen ACF for Adapter/Charger Applications**
Xiucheng Huang
Navitas, United States

9:45 a.m. – 10:10 a.m.

IS16.4 **Real World High Voltage GaN Design Experiences**
Philip Zuk
Transphorm, United States

10:10 a.m. – 10:35 a.m.

Break

10:35 a.m. – 11:00 a.m.

IS16.5 **Super High Efficiency SHE2 Telecom Rectifier Provides Record Efficiency With Cost Effective GaN Based Power Conversion**
Eric Persson
Infineon Technologies, United States

11:00 a.m. – 11:25 a.m.

IS16.6 **GaN E-HEMT Performance and Reliability in Datacenter, Solar, and Wireless Power Production Systems**
Jim Witham
GaNSystems, United States

8:30 a.m. – 11:25 a.m.

IS17: SiC Applications

ROOM 210D

CHAIRS:

Jeff Casady, *Wolfspeed*

Chris Jones, *Artesyn*

8:30 a.m. – 8:55 a.m.

IS17.1 **Reliability of Silicon Carbide Power Modules using POL-kW Packaging Technology**
Liqiang Yang[2], Rick Eddins[2], Robert George[2], Christopher Kapusta[2], Liang Yin[2], Kaustubh Nagarkar[2], Arun Gowda[1], Risto Tuominen[2], Dave Esler[1]
[1]GE Global Research, United States; [2]General Electric, United States

8:55 a.m. – 9:20 a.m.

IS17.2 **A High Efficiency 3-Phase 400V 15kW Power Inverter using SiC MOSFETs and Trans-Linked Topology**
Tatsuya Miyazaki[3], Yuta Okawauchi[2], Hirotaka Otake[2], Ken Nakahara[2], Mamoru Tsuruya[1]
[1]Power Assist Technology Co., Ltd., Japan; [2]Rohm Co., Ltd., Japan; [3]ROHM Semiconductor, Japan

9:20 a.m. – 9:45 a.m.

IS17.3 **High Efficiency 60kW Boost Converter for Solar Power Generation**
Julius Rice
Wolfspeed (a Cree Company), United States

9:45 a.m. – 10:10 a.m.

IS17.4 **SiC MOSFET or Si IGBT in Industrial Motor Drives?**
Carmelo Parisi, Antonino Raciti, Angelo Giuseppe Sciacca, Mario Pulvirenti
STMicroelectronics, Italy

10:10 a.m. – 10:35 a.m.

Break

10:35 a.m. – 11:00 a.m.

IS17.5 **An Experimental Investigation of the SiC MOSFET Gate Voltage Glitches with Miller Clamp**
Anselmo Gianluca Liberti, Giuseppe Catalisano
STMicroelectronics, Italy

11:00 a.m. – 11:25 a.m.

IS17.6 **SiC Modules with and Without External Diodes**
Kevork Haddad
SEMIKRON Inc, United States

8:30 a.m. – 11:25 a.m.

IS18: Magnetics

ROOM 210A

CHAIRS:

George Slama, *Würth Elektronik*

Carl Walker, *Artesyn*

8:30 a.m. – 8:55 a.m.

IS18.1 **Power Transformer Core Optimization Enables Dramatically Increased Power Density**
John Gallagher, David Munguia, Harvey Xu
Pulse Electronics, United States; Pulse Electronics, Canada

8:55 a.m. – 9:20 a.m.

IS18.2 **3DPower™ A Tech Disruption in Power Electronics**
Claudio Cabeza, Patrick Fouassier
PREMO, Spain; PREMO, France

9:20 a.m. – 9:45 a.m.

IS18.3 **High-Flux Density Nanocrystalline Materials for High-Frequency Power Applications**
Cathal Sheehan[1], Asnar Masood[2], Zoran Pavlovic[2], Hasan Baghbaderani[2], P. Stamenov[2], Paul McCloskey[2]
[1]Bourns, Ireland; [2]Tyndall, Ireland

9:45 a.m. – 10:10 a.m.

IS18.4 **An Analysis and Optimization Tool for High-Frequency Power Magnetics**
Michael Seeman
Eta One Power, United States

10:10 a.m. – 10:35 a.m.

Break

10:35 a.m. – 11:00 a.m.

IS18.5 **Finite Element Modeling of Switch Mode Power Supply Magnetics**
Weyman Lundquist, Shuang Feng, Mary Clark
West Coast Magnetics, United States

11:00 a.m. – 11:25 a.m.

IS18.6 **High Frequency Inductors for GaN Applications: Construction Analysis and Efficiency Comparison**
John Gallagher, David Munguia
Pulse Electronics, United States; Pulse Electronics, Canada

8:30 a.m. – 11:25 a.m.

IS19: Advances in the Adoption of Wide Band Gap Semiconductors in Commercial & Industrial Applications

ROOM 210BC

CHAIR:

James LeMunyon, *PowerAmerica*

8:30 a.m. – 8:55 a.m.

IS19.1 **Designing with UnitedSiC FETs**
Pete Losee
United Silicon Carbide, United States

8:55 a.m. – 9:20 a.m.

IS19.2 **WBG Automotive Inverters and Chargers**
Kevin Bai
University of Tennessee-Knoxville, United States

9:20 a.m. – 9:45 a.m.

IS19.3 **Applications for WBG Devices**
Georgios Demetriades
ABB, United States

9:45 a.m. – 10:10 a.m.

IS19.4 **GaN Power IC Adoption Takes off in Fast Charging Market**
Dan Kinzer
Navitas Semiconductor, United States

8:30 a.m. – 11:25 a.m.

IS20: Applications

ROOM 213B

CHAIRS:

Darshan Ghandi, *Navitas Semi*

Davide Giacomini, *Infineon Technologies*

8:30 a.m. – 8:55 a.m.

IS20.1 **Application Considerations of the Three-Level ANPC Topology**
Paul Drexhage
SEMIKRON Inc., United States

8:55 a.m. – 9:20 a.m.

IS20.2 **SOI Level-Shift Gate-Drive IC in LED Lighting Application**
Weidong Chu
employee of Infineon Technologies, United States

9:20 a.m. – 9:45 a.m.

IS20.3 **Design and Measurement of High Power Nanosecond Pulse Circuits for Laser Drivers**
John Glaser
Efficient Power Conversion, United States

9:45 a.m. – 10:10 a.m.

IS20.4 **A 5kW Low Voltage Drive System for Industrial Motor Control Applications**
Gennaro Macina
STMicroelectronics, Italy

10:10 a.m. – 10:35 a.m.

Break

10:35 a.m. – 11:00 a.m.

IS20.5 **850W Quarter Brick using 3milliohm 100 V MV GaN fet**
Moshe Domb
Infineon Technologies, United States

11:00 a.m. – 11:25 a.m.

IS20.6 **The Film Capacitors Technology for DC Link**
Anvy Chen
Xiamen Faratronic CO. LTD., China

1:45 p.m. – 3:25 p.m.

IS21: GaN Integration

ROOM 210D

CHAIR:

Dilip Rosbud, *Dialog Semi*

1:45 p.m. – 2:10 p.m.

IS21.1 **Fully Integrated GaN-on-Si Technology Targeting On-Chip 48V Input Power Conversion**
Ko-Tao Lee[1], Xin Zhang[1], Todd Takken[1], Effendi Leobandung[1], Devendra Sadana[1], Daniel Piedra[2], Tomas Palacios[2]
[1]IBM, United States; [2]Massachusetts Institute of Technology, United States

2:10 p.m. – 2:35 p.m.

IS21.2 **GaN Technology up to Speed: Monolithic GaN Power IC**
Mike Wens, Jef Thoné
MinDCet NV, Belgium

2:35 p.m. – 3:00 p.m.

IS21.3 **A New 650V GaNFast Half Bridge IC for AC/DC Converter Applications**
Santosh Sharma[2], Kedar Patel[1], Marco Giandalia[2]
[1]Navitas Semiconductor Inc, United States; [2]Navitas Semiconductor Inc., United States

3:00 p.m. – 3:25 p.m.

IS21.4 **Passive Components for PCB and Substrate Embedding**
Vern Solberg
Solberg Technical Consulting, United States

1:45 p.m. – 3:25 p.m.

IS22: Components

ROOM 210A

CHAIR:

Reenu Garg, *Infineon Technologies*

1:45 p.m. – 2:10 p.m.

IS22.1 **Powering Autonomous Sensors for Industry 4.0 with Solid State Batteries**
Denis Pasero
Ilika Technologies, United Kingdom

2:10 p.m. – 2:35 p.m.

IS22.2 **Matching SiC MOSFET Spice Model Simulation Switching Loss with Hardware Testing**
Teik Siang Ong
Wolfspeed, A Cree Company, United States

2:35 p.m. – 3:00 p.m.

IS22.3 **Fulfilling the Vision Transformerless ("TL") Conversion**
Harold Blomquist
Helix Semiconductors, United States

3:00 p.m. – 3:25 p.m.

IS22.4 **Characterization of the Humidity Effect in Film Capacitors Lifetime for Solar Application Applying the Calibrated Accelerated Life Test (CALT) Method**
Andrea Bianchi, Stefano Carboni
ABB, Italy

1:45 p.m. – 3:25 p.m.

IS23: Test

ROOM 213B

CHAIR:

Greg Evans, *WelComm Inc.*

1:45 p.m. – 2:10 p.m.

IS23.1 **Filter Attenuation Measurement Method using Electrical Fast Transient Burst (EFTB)**
Jared Quenzer[2], Richard Spangenberg[1]
[1]Schneider Electric, United States; [2]Wurth Electronics, United States

2:10 p.m. – 2:35 p.m.

IS23.2 **Continuous Operation Evaluation Platform for SiC MOSFETs and Diodes**
Christophe Warin, Xuning Zhang, Gin Sheh, Sujit Banerjee
Littelfuse Inc., United States

2:35 p.m. – 3:00 p.m.

IS23.3 **Green Power Supply Testing with Regenerative Electronic Loads**
Eric Turner
EA Electro-Automatik, Inc., United States

3:00 p.m. – 3:25 p.m.

IS23.4 **Electrical Safety Testing of Electronic Equipment**
Chad Clark
Vitrek, United States

TECHNICAL SESSIONS

APEC professionals like you participated in a rigorous peer review process and have carefully picked over 500 papers making up APEC's Technical Sessions. The review process highlights the most innovative technical solutions, and provides the highest quality possible. The technical program includes papers of broad appeal scheduled for oral presentation from Tuesday morning through Thursday afternoon. Papers with a more specialized focus are available for discussion witha uthors at the dialogue session on Thursday from 11:30 a.m. – 2:00 p.m. The various technical venues cover all areas of technical interest to the practicing power electronics professional. The papers are sure to give you many new design ideas that you can apply to your work immediately.

8:30 a.m. – 11:15 a.m.

T25: Multilevel and Multi-Phase AC-DC Converters

ROOM 211AB

AC-DC Converters

CHAIRS:

Michael A.E. Andersen, *Technical University of Denmark*

Daniel J. Costinett, *University of Tennessee*

8:30 a.m. – 8:50 a.m.

T25.1 **Derivation of DCM/CCM Boundary and Ideal Duty-Ratio Feedforward for Three-Level Boost Rectifier**
Moonhyun Lee, Jong-Woo Kim, Jih-Sheng Jason Lai
Virginia Polytechnic Institute and State University, United States

8:50 a.m. – 9:10 a.m.

T25.2 **A 6-Level Flying Capacitor Multi-Level Converter for Single Phase Buck-Type Power Factor Correction**
Enver Candan[3], Andrew Stillwell[3], Nathan C. Brooks[2], Rose A. Abramson[2], Johan Strydom[1], Robert Pilawa-Podgurski[2]
[1]Texas Instruments Inc., United States; [2]University of California, Berkeley, United States; [3]University of Illinois at Urbana-Champaign, United States

9:10 a.m. – 9:30 a.m.

T25.3 **Switching Performance Evaluation and Loss Analysis of SiC-Based Neutral Point Clamped Bidirectional AC/DC Converter**
Yang Jiao, Milan Jovanović, Zhiyu Shen
Delta Electronics Ltd., United States

9:30 a.m. – 9:50 a.m.

T25.4 **Design and Implementation of Forced Air-Cooled, 140kHz, 20kW SiC MOSFET Based Vienna PFC**
Siyuan Chen[2], Wensong Yu[2], Dennis Meyer[1]
[1]Microsemi, United States; [2]North Carolina State University, United States

9:50 a.m. – 10:10 a.m.

T25.5 **Universal Zero-Voltage-Switching Technique for Multi-Phase AC/DC Converter**
Jinyi Deng, Keyan Shi, An Zhao, Dehong Xu
Zhejiang University, China

10:10 a.m. – 10:35 a.m.

Break

10:35 a.m. – 10:55 a.m.

T25.6 **A Balanced, Unity Power Factor, 3-Phase Bridgeless AC/DC Step-Up Transformer-Less Converter with Magnetic-Coupled Soft-Switched Step-Up Rectifiers for Wind Farm with a MVDC Grid**
Mehdi Abbasi, John Lam
York University, Canada

10:55 a.m. – 11:15 a.m.

T25.7 **A Fault Tolerant Three-Phase Isolated AC-DC Converter**
Javad Khodabakhsh, Gerry Moschopoulos
Western University, Canada

8:30 a.m. – 11:15 a.m.

T26: Magnetics Modeling, Design & Applications

ROOM 212AB

Modeling and Simulation

CHAIRS:

Fang Luo, *University of Arkansas*

Shuo Wang, *University of Florida*

8:30 a.m. – 8:50 a.m.

T26.1 **Optimization of PCB Layout for 1-MHz High Step-Up/Down LLC Resonant Converters**
Xiaonan Zhao, Cheng-Wei Chen, Jih-Sheng Jason Lai
Virginia Polytechnic Institute and State University, United States

8:50 a.m. – 9:10 a.m.

T26.2 **Modeling the Effects of Printed-Circuit-Board Parasitics on the Switching Performance of Wide-Bandgap Applications**
Jan Hammer[2], Martin Ordonez[2], Peter Ksiazek[1]
[1]Alpha Technologies Ltd., Canada; [2]University of British Columbia, Canada

9:10 a.m. – 9:30 a.m.

T26.3 **Comprehensive SPICE Model for Power Inductor Losses**
Stefan Ehrlich, Christopher Joffe, Hannes Thielke, Matthias Leinfelder, Martin März
Fraunhofer IISB, Germany

9:30 a.m. – 9:50 a.m.

T26.4 **A Simple Analytical Technique for Evaluating the 2-D Conductive Losses in Isolated Rectangular Conductor**
Xiaohui Wang, Li Wang, Ling Mao, Yaojia Zhang
Nanjing University of Aeronautics and Astronautics, China

9:50 a.m. – 10:10 a.m.

T26.5 **An Improved Design Method for Gapped Inductors Considering Fringing Effect**
Zhe Yang[2], Harish Suryanarayana[1], Fred Wang[2]
[1]ABB Inc., United States; [2]University of Tennessee, United States

10:10 a.m. – 10:35 a.m.

Break

10:35 a.m. – 10:55 a.m.

T26.6 **Simple Fully Analytical Copper Loss Model of Litz Wire Made of Strands Twisted in Multiple Levels**
Kazuhiro Umetani[1], Jesus Acero[2], Hector Sarnago[2], Oscar Lucia[2], Eiji Hiraki[1]
[1]Okayama University, Japan; [2]Universidad de Zaragoza, Spain

10:55 a.m. – 11:15 a.m.

T26.7 **Modeling of Conducted Emission for an Automotive Motor Control Inverter**
Ali Safayet, Mohammad Islam
Halla Mechatronics, United States

8:30 a.m. – 11:15 a.m.

T27: Step-up DC-DC Converters

ROOM 213C

DC-DC Converters

CHAIRS:

Wisam Moussa, *Infineon*

Gab-Su Seo, *National Renewable Energy Laboratory*

8:30 a.m. – 8:50 a.m.

T27.1 **High Efficiency High Step-Up Isolated DC-DC Converter for Photovoltaic Applications**
Chang Wang[2], Mingxiao Li[2], Ziwei Ouyang[2], Gang Wang[1]
[1]Institute of Electrical Engineering Chinese Academy of Sciences, China; [2]Technical University of Denmark, Denmark

8:50 a.m. – 9:10 a.m.

T27.2 **Ultra-High Power Density Full-SiC Boost Converter Enabled by Advanced 3D-Printing Techniques**
Arne Hendrik Wienhausen, Alexander Sewergin, Rik W. De Doncker
RWTH Aachen University, Germany

9:10 a.m. – 9:30 a.m.

T27.3 **Step-Up Converter with High Order Selectivity**
Gwangyol Noh, Jun Lee, Jung-Ik Ha
Seoul National University, Korea

9:30 a.m. – 9:50 a.m.

T27.4 **Multiphase Interleaved High Step-Up Converters**
Yifei Zheng[2], Wenhao Xie[1], Keyue Smedley[2]
[1]Harbin Institute of Technology, United States; [2]University of California, Irvine, United States

9:50 a.m. – 10:10 a.m.

T27.5 **Analysis and Design of a High Step-Up Transformerless DC-DC Converter with an Integrated $L^2C^3D^2$ Network**
Nour Elsayad, Hadi Moradisizkoohi, Osama Mohammed
Florida International University, United States

10:10 a.m. – 10:35 a.m.

Break

10:35 a.m. – 10:55 a.m.

T27.6 **DC-Shifted Harmonics-Boosted Resonant DC-DC Converter with High-Step-Up Conversion Ratio with ZVS Over the Full Load Range**
Kerui Li[2], Siew-Chong Tan[2], Adrian Ioinovici[1]
[1]Holon Institute of Technology, Israel; [2]University of Hong Kong, Hong Kong

10:55 a.m. – 11:15 a.m.

T27.7 **Integrated High-Efficiency Single-Inductor CCM Boost Converter for Multi-Junction PV Energy Harvesting**
Qirong Peng, Debashis Mandal, Parisa Mahmoudidaryan, Bertan Bakkaloglu, Sayfe Kiaei
Arizona State University, United States

8:30 a.m. – 11:15 a.m.

T28: Control Strategies for Improving Quality and Performance

ROOM 213D

Control

CHAIRS:

Seungdeog Choi, *Mississippi State University*

Panagiotis Kakosimos, *ABB AB Corporate Research*

8:30 a.m. – 8:50 a.m.

T28.1 **Optimized IGBT Turn-Off Switching Performance Using the Full Device Safe Operating Area**
Christoph Lüdecke, Georges Engelmann, Rik W. De Doncker
RWTH Aachen University, Germany

8:50 a.m. – 9:10 a.m.

T28.2 **A Fast Transient Flip Voltage Follower Based Low Dropout Regulator with AC-Coupled Pseudo Tri-Loop Technique Without Using Any Output Capacitor**
Tzu-Hao Chien, Ching-Jan Chen, Sheng-Teng Li, Chieh-Ju Tsai
National Taiwan University, Taiwan

9:10 a.m. – 9:30 a.m.

T28.3 **Control Strategy of Active Storage Unit in Pulsed Load AC Input System to Reduce DC Bus Capacitance**
Lei Bai, Xiaoyong Ren, Yu Chen, Zhiliang Zhang, Qianhong Chen, Xin Cao
Nanjing University of Aeronautics and Astronautics, China

9:30 a.m. – 9:50 a.m.

T28.4 **A Simple Control to Reduce Device Over-Voltage Caused by Non-Active Switch Loop in Three-Level ANPC Converters**
Handong Gui[2], Zheyu Zhang[2], Ruirui Chen[2], Ren Ren[2], Jiahao Niu[2], Bo Liu[2], Haiguo Li[2], Zhou Dong[2], Fred Wang[2], Leon M. Tolbert[2], Benjamin J. Blalock[2], Daniel J. Costinett[2], Benjamin B. Choi[1]
[1]NASA Glenn Research Center, United States; [2]University of Tennessee, United States

9:50 a.m. – 10:10 a.m.

T28.5 **Constant on-Time Multi-Mode Digital Control with Superior Performance and Programmable Frequency**
K Hariharan, Santanu Kapat, Siddhartha Mukhopadhyay
Indian Institute of Technology Kharagpur, India

10:10 a.m. – 10:35 a.m.

Break

10:35 a.m. – 10:55 a.m.

T28.6 **Online Impedance Measurement of Cascaded DC/DC Converters**
Marlon Granda[1], Cristina Fernandez[1], Pablo Zumel[1], Angel Fernandez-Herrero[2], Andres Barrado[1]
[1]Universidad Carlos III de Madrid, Spain; [2]Universidad Politécnica de Madrid, Spain

10:55 a.m. – 11:15 a.m.

T28.7 **Continuous Stability Monitoring of DC Microgrids Using Controlled Injection**
Rohail Hassan, Hongjie Wang, Regan Zane
Utah State University, United States

8:30 a.m. – 11:15 a.m.

T29: SiC & GaN Based Power Converters

ROOM 303AB

Power Electronics Integration and Manufacturing

CHAIRS:

Victor Veliadis, *North Carolina State University*

Qing Ye, *Toshiba International Corporation*

8:30 a.m. – 8:50 a.m.

T29.1 **Enhanced Heat Transfer Performance with Designed Pin Fin Cold Plate for 50 kW High Power Density Converter**
Lingxi Zhang[2], Ziyou Lim[2], Arie Nawawi[2], Yong Liu[2], Josep Pou[1], Rejeki Simanjorang[3]
[1]Nanyang Technological University, Singapore; [2]Rolls-Royce at NTU Corporate Lab, Nanyang Technological University, Singapore; [3]Rolls-Royce Electrical, Rolls-Royce Singapore Pte. Ltd, Singapore

8:50 a.m. – 9:10 a.m.

T29.2 **Design of an Advanced Programmable Current-Source Gate Driver for Dynamic Control of SiC Device**
Xiang Wang, Haimeng Wu, Volker Pickert
Newcastle University, United Kingdom

9:10 a.m. – 9:30 a.m.

T29.3 **Comparison of Radiated Electromagnetic Interference (EMI) Generated by Power Converters with Silicon MOSFETs and GaN HEMTs**
Yingjie Zhang[2], Shuo Wang[2], Yongbin Chu[1]
[1]Texas Instruments Inc., United States; [2]University of Florida, United States

9:30 a.m. – 9:50 a.m.

T29.4 **A Manifold Microchannel Heat Sink for Ultra-High Power Density Liquid-Cooled Converters**
Remco van Erp, Georgios Kampitsis, Elison Matioli
École Polytechnique Fédérale de Lausanne, Switzerland

9:50 a.m. – 10:10 a.m.

T29.5 **Design of a High-Performance DC Power Cycling Test Setup for SiC MOSFETs Based on Switching Transient Analysis**
Fei Yang, Enes Ugur, Shi Pu, Bilal Akin
University of Texas at Dallas, United States

10:10 a.m. – 10:35 a.m.

Break

10:35 a.m. – 10:55 a.m.

T29.6 **A 30kW Three-Phase Voltage Source Inverter Based on the Si IGBT/SiC MOSFET Hybrid Switch**
Lei Li, Puqi Ning, Xuhui Wen, Qiongxuan Ge, Yaohua Li
Institute of Electrical Engineering, Chinese Academy of Sciences, China

10:55 a.m. – 11:15 a.m.

T29.7 **Packaging Solution for SiC Power Modules with a Fail-to-Short Capability**
Ilyas Dchar[3], Cyril Buttay[1], Hervé Morel[2]
[1]Institut National des Sciences Appliquées de Lyon, France; [2]Laboratoire Ampere/CNRS, France; [3]Supergrid Institute, France

8:30 a.m. – 11:15 a.m.

T30: Magnetics Optimization

ROOM 303CD

Devices and Components

CHAIRS:

Seung R. Moon, *Nat'l Energy Technology Laboratory*

Matthew Wilkowski, *Enachip*

8:30 a.m. – 8:50 a.m.

T30.1 **Effects of Secondary Leakage Inductance on the LLC Resonant Converter—Part II: Frequency Control Bandwidth with Respect to Load Variation**
Mostafa Noah[1], Tomohide Shirakawa[2], Kazuhiro Umetani[2], Jun Imaoka[1], Masayoshi Yamamoto[1], Eiji Hiraki[2]
[1]Nagoya University, Japan; [2]Okayama University, Japan

8:50 a.m. – 9:10 a.m.

T30.2 **Computer-Aided Design and Optimization of an Integrated Transformer with Distributed Air Gap and Leakage Path for an LLC Resonant Converter**
Lukas Keuck, Frank Schafmeister, Joachim Böcker
Universität Paderborn, Germany

9:10 a.m. – 9:30 a.m.

T30.3 **Design Guidelines for High-Power and High-Frequency Transformers**
Guillermo Salinas[2], Álvaro Giménez[1], Jesús Angel Oliver[2], Roberto Prieto[2]
[1]SENER Ingeniería y Sistemas, Spain; [2]Universidad Politécnica de Madrid, Spain

9:30 a.m. – 9:50 a.m.

T30.4 **Improved Partial Cancellation Method for High Frequency Core Loss Measurement**
Feiyang Zhu, Qiang Li, Fred C. Lee
Virginia Polytechnic Institute and State University, United States

9:50 a.m. – 10:10 a.m.

T30.5 **First Observations in Degradation Testing of Planar Magnetics**
Zhan Shen, Qian Wang, Yanfeng Shen, Huai Wang
Aalborg University, Denmark

10:10 a.m. – 10:35 a.m.

Break

10:35 a.m. – 10:55 a.m.

T30.6 **Magnetic Optimizations for High-Power Density Bidirectional Cascaded-Buck-Boost Converter**
Xi Chen, Anirudh Ashok Pise, Issa Batarseh
University of Central Florida, United States

10:55 a.m. – 11:15 a.m.

T30.7 **Optimized Design of Integrated PCB-Winding Transformer for MHz LLC Converter**
Yinsong Cai, Mohamed H. Ahmed, Qiang Li, Fred C. Lee
Virginia Polytechnic Institute and State University, United States

8:30 a.m. – 11:15 a.m.

T31: Control Algorithms for Utility Interactive Systems

ROOM 304AB

Power Electronics for Utility Interface

CHAIRS:

Praveen Jain, *Queen's University*

Xiongfei Wang, *Aalborg University*

8:30 a.m. – 8:50 a.m.

T31.1 **Design and Analysis of a Current-Controlled Virtual Synchronous Machine for Weak Grids**
Javier Roldán-Pérez[1], Adrian González-Cajigas[2], Alberto Rodríguez-Cabero[1], Milan Prodanovic[1], Pablo Zumel[2]
[1]IMDEA Energy Institute, Spain; [2]Universidad Carlos III de Madrid, Spain

8:50 a.m. – 9:10 a.m.

T31.2 **A Model Predictive Voltage Control Using Virtual Space Vectors for Grid-Forming Energy Storage Converters**
Waleed Alhosaini, Yue Zhao
University of Arkansas, United States

9:10 a.m. – 9:30 a.m.

T31.3 **A New Power Flow Control Method for Energy Storage Systems in Microgrids (MGs)**
Hadis Hajebrahimi, Sajjad Makhdoomi Kaviri, Suzan Eren, Alireza Bakhshai
Queen's University, Canada

9:30 a.m. – 9:50 a.m.

T31.4 **Anti-Islanding Detection Method Using Phase Shifted Feed-Forward Voltage**
Dong-Uk Kim, Sungmin Kim
Hanyang University, Korea

9:50 a.m. – 10:10 a.m.

T31.5 **Smart Loads for Power Quality and Battery Lifetime Improvement in Nanogrids**
Mohsen S. Pilehvar, Mohammad B. Shadmand, Behrooz Mirafzal
Kansas State University, United States

10:10 a.m. – 10:35 a.m.

Break

10:35 a.m. – 10:55 a.m.

T31.6 **Seamless Transfer of Control Mode for Modular Multilevel Converter with Integrated Battery Energy Storage System**
Zhe Wang, Hua Lin, Yajun Ma, Zuyao Ze, Tao Wang
Huazhong University of Science and Technology, China

10:55 a.m. – 11:15 a.m.

T31.7 **Power Flow Control in Multi-Active-Bridge Converters: Theories and Applications**
Yenan Chen[1], Ping Wang[1], Haoran Li[2], Minjie Chen[1]
[1]Princeton University, United States; [2]Tsinghua University, China

8:30 a.m. – 11:15 a.m.

T32: Wireless Power Transfer Design Techniques

ROOM 304CD

Wireless Power Transfer

CHAIRS:

Wisam Alhoor, *Dialog Semiconductor*

Faisal Khan, *University of Missouri at Kansas City*

8:30 a.m. – 8:50 a.m.

T32.1 **A 5kW Bi-Directional Wireless Charger for Electric Vehicles with Electromagnetic Coil Based Self-Alignment**
Hirokazu Matsumoto, Nameer Khan, Olivier Trescases
University of Toronto, Canada

8:50 a.m. – 9:10 a.m.

T32.2 **Optimized Design for Wireless Coil for Electric Vehicles Based on the Use of Magnetic Nano-Particles**
Alberto Delgado[2], Jesús Angel Oliver[2], José Antonio Cobos[2], Jorge Rodriguez[1], Alejandro Jiménez[1]
[1]Grupo Premo, Spain; [2]Universidad Politécnica de Madrid, Spain

9:10 a.m. – 9:30 a.m.

T32.3 **Design of an EMF Suppressing Magnetic Shield for a 100-kW DD-Coil Wireless Charging System for Electric Vehicles**
Mostak Mohammad[3], Jason L. Pries[1], Omer C. Onar[1], Veda Prakash N. Galigekere[1], Gui-Jia Su[1], Saeed Anwar[4], Jonathan Wilkins[1], Utkarsh Dilip Kavimandan[2], Devendra Patil[5]
[1]Oak Ridge National Laboratory, United States; [2]Tennessee Technological University, United States; [3]University of Akron, United States; [4]University of Tennessee, United States; [5]University of Texas at Dallas, United States

9:30 a.m. – 9:50 a.m.

T32.4 **An Optimized Parameter Design Method of WPT System for EV Charging Based on Optimal Operation Frequency Range**
Yongbin Jiang, Min Wu, Shiyuan Yin, Zhongfang Wang, Laili Wang, Yue Wang
Xi'an Jiaotong University, China

9:50 a.m. – 10:10 a.m.

T32.5 **High-Efficiency High-Power-Transfer-Density Capacitive Wireless Power Transfer System for Electric Vehicle Charging Utilizing Semi-Toroidal Interleaved-Foil Coupled Inductors**
Brandon Regensburger[1], Ashish Kumar[3], Sreyam Sinha[1], Jiale Xu[2], Khurram Afridi[1]
[1]Cornell University, United States; [2]Stanford University, United States; [3]University of Colorado Boulder, United States

10:10 a.m. – 10:35 a.m.

Break

10:35 a.m. – 10:55 a.m.

T32.6 **Feasibility Analysis of Nanocrystalline Cores for Polarized and Non-Polarized IPT Charging Pads**
Daniel Gaona, Teng Long
University of Cambridge, United Kingdom

10:55 a.m. – 11:15 a.m.

T32.7 **Combined Foreign Object Detection and Live Object Protection in Wireless Power Transfer Systems via Real-Time Thermal Camera Analysis**
Timothy Sonnenberg, Adam Stevens, Alireza Dayerizadeh, Srdjan Lukic
North Carolina State University, United States

1:45 p.m. – 5:00 p.m.

T33: DC-DC Converter Applications

ROOM 211AB

DC-DC Converters

CHAIRS:

Zach Pan, *ABB US Corporate Research Center*

Olivier Trescases, *University of Toronto*

1:45 p.m. – 2:05 p.m.

T33.1 **75 MHz Discrete GaN Based Multi-Level Buck Converter for Envelope Tracking Applications**
Alejandro Villarruel-Parra, Andrew Forsyth
University of Manchester, United Kingdom

2:05 p.m. – 2:25 p.m.

T33.2 **An 86% Efficiency, 20MHz, 3D-Integrated Buck Converter with Magnetic Core Inductor Embedded in Interposer Fabricated by Epoxy/Magnetic-Filler Composite Build-Up Sheet**
Takanobu Fukuoka, Yuki Karasawa, Tomoki Akiyama, Ryoutaro Oka, Shu Ishida, Tomohiro Shirasawa, Makoto Sonehara, Toshiro Sato, Kousuke Miyaji
Shinshu University, Japan

2:25 p.m. – 2:45 p.m.

T33.3 **A Novel Filter Built-in Isolated Bi-Directional DC-DC Converter with Split Windings**
Shuntaro Inoue, Masanori Ishigaki, Atsuhiro Takahashi, Takahide Sugiyama
Toyota Central R&D Labs., Inc., Japan

2:45 p.m. – 3:05 p.m.

T33.4 **A Wide Operating Range Converter Using a Variable-Inverter-Rectifier-Transformer with Improved Step-Down Capability**
Intae Moon[1], Mike Ranjram[1], Sombuddha Chakraborty[2], David J. Perreault[1]
[1]Massachusetts Institute of Technology, United States; [2]Texas Instruments Inc., United States

3:05 p.m. – 3:25 p.m.

T33.5 **High Efficiency and High Power Density Weinberg Converter Reducing Conduction Loss and Output Current Ripple for Space Applications**
Dong-Kwan Kim[1], Yeonho Jeong[5], Jae-Il Baek[3], Jeong-Eon Park[2], Cheol-Woo Lim[4], Gun-Woo Moon[1]
[1]KAIST, Korea; [2]Korea Aerospace research Institute, Korea; [3]Princeton University, United States; [4]Satellite Technology Research Center, Korea; [5]University of Colorado Denver, United States

3:25 p.m. – 3:40 p.m.

Break

3:40 p.m – 4:00 p.m.

T33.6 **Practical Implementation and Efficiency Evaluation of a Phase Shifted Full Bridge DC-DC Converter Using Radiation Hardened GaN FETs for Space Applications**
Victor Turriate[1], Brandon Witcher[2], Dushan Boroyevich[1], Rolando Burgos[1]
[1]Virginia Polytechnic Institute and State University, United States; [2]VPT Inc., United States

4:00 p.m. – 4:20 p.m.

T33.7 **Hardware Implementation of a New Single Input Double Output L-L Converter for High Voltage Auxiliary Loads in Fuel-Cell Vehicles**
Mahajan Sagar Bhaskar[2], Lazhar Ben-Brahim[2], Atif Iqbal[2], Sanjeevikumar Padmanaban[1], Mohammad Meraj[2], Syed Rahman[2]
[1]Aalborg University, Denmark; [2]Qatar University, Qatar

4:20 p.m. – 4:40 p.m.

T33.8 **Highly Efficient EV Battery Charger Using Fractional Charging Concept with SiC Devices**
Tore Kanstad, Morten Birkerod Lillholm, Zhe Zhang
Technical University of Denmark, Denmark

4:40 p.m .– 5:00 p.m.

T33.9 **Ultra-High Power Density Magnetic-Less DC/DC Converter Utilizing GaN Transistors**
Georgios Kampitsis, Remco van Erp, Elison Matioli
École Polytechnique Fédérale de Lausanne, Switzerland

1:45 p.m. – 5:00 p.m.

T34: Soft Switching DC-DC Converters

ROOM 212AB

DC-DC Converters

CHAIRS:

Hanh-Phuc Le, *University of Colorado at Boulder*

Chenhao Nan, *Google*

1:45 p.m. – 2:05 p.m.

T34.1 **Accurate Discrete-Time Modeling of an Interleaved Current-Fed Dual Active Bridge DC-DC Converter**
Avishek Pal, Santanu Kapat
Indian Institute of Technology Kharagpur, India

2:05 p.m. – 2:25 p.m.

T34.2 **An Optimized Control Scheme to Reduce the Backflow Power and Peak Current in Dual Active Bridge Converters**
Bochen Liu, Pooya Davari, Frede Blaabjerg
Aalborg University, Denmark

2:25 p.m. – 2:45 p.m.

T34.3 **Extended Operational Range of Dual-Active-Bridge Converters by Using Variable Magnetic Devices**
Sarah Saeed, Jorge García
University of Oviedo, Spain

2:45 p.m. – 3:05 p.m.

T34.4 **Frequency-Controlled Resonant Converter with Push-Pull Class-E Inverter**
Shohei Saito[1], Shohei Mita[1], Hiroyuki Onishi[2], Shingo Nagaoka[2], Takeshi Uematsu[2], Hiroo Sekiya[1]
[1]Chiba University, Japan; [2]OMRON Corporation, Japan

3:05 p.m. – 3:25 p.m.

T34.5 **Partial Parallel Dual Active Bridge Converter with Variable Voltage Gain for SOEC/SOFC System**
Yudi Xiao[1], Zhe Zhang[1], Michael A. E. Andersen[1], Brian Engelbrecht Thomsen[2]
[1]Technical University of Denmark, Denmark; [2]Welltec A/S, Denmark

3:25 p.m. – 3:40 p.m.

Break

3:40 p.m – 4:00 p.m.

T34.6 **Soft Switching Method of TPS Modulated DAB Converters with Wide Band Gap Devices**
Chi Shao[1], Kai Shen[1], Anping Tong[2], Shenhua Zhang[3], Yuanbin He[1], Lijun Hang[1]
[1]Hangzhou Dianzi University, China; [2]Shanghai Jiao Tong University, China; [3]Xi'an Jiaotong University, China

4:00 p.m. – 4:20 p.m.

T34.7 **Single-Turn Air-Core Integrated Planar Inductor for GaN HEMT-Based Zero-Voltage Switching Synchronous Buck Converter**
Woongkul Lee, Di Han, Bulent Sarlioglu
University of Wisconsin-Madison, United States

4:20 p.m. – 4:40 p.m.

T34.8 **A Pareto-Optimized, Capacitively Isolated SEPIC Converter for Wide Load Ranges and High Frequency Power Conversion**
Dennis Bura[1], Thomas Plum[1], Rik W. De Doncker[2]
[1]Robert Bosch GmbH, Germany; [2]RWTH Aachen University, Germany

4:40 p.m .– 5:00 p.m.

T34.9 **A Soft-Switching Isolated Buck-Boost Converter with Semi-Active Rectifier for Wide Output Range Application**
Yuzheng Xia[1], Jijun Ma[2], Yan Xing[1], Yuhui Ji[2], Baolin Chen[1], Hongfei Wu[1]
[1]Nanjing University of Aeronautics and Astronautics, China; [2]Shanghai Institute of Space Power-Sources, China

1:45 p.m. – 5:00 p.m.

T35: Power Electronics for Transportation

ROOM 213C

Transportation Power Electronics

CHAIRS:

Behrooz Mirafzal, *Kansas State University*

Omer Onar, *Oak Ridge National Laboratory*

1:45 p.m. – 2:05 p.m.

T35.1 **Isolated, Bi-Directional DC-DC Converter for Fuel Cell Electric Vehicle Applications**
Yungtaek Jang[2], Milan Jovanović[2], Misha Kumar[2], Juan Ruiz[2], Robert Lu[1], Tony Wei[1]
[1]Delta Electronics Co., Ltd., China; [2]Delta Electronics Ltd., United States

2:05 p.m. – 2:25 p.m.

T35.2 **A GaN Switched Tank Converter with Partial Power Voltage Regulation for Electric Vehicle Applications**
Ze Ni[2], Yanchao Li[2], Jalen Johnson[2], Mengxuan Wei[2], Chengkun Liu[2], Xiaofeng Lyu[1], Dong Cao[2]
[1]Navitas Semiconductor, United States; [2]North Dakota State University, United States

2:25 p.m. – 2:45 p.m.

T35.3 **A 100kW Switched-Tank Converter for Electric Vehicle Application**
Yanchao Li, Ze Ni, Chengkun Liu, Mengxuan Wei, Dong Cao
North Dakota State University, United States

2:45 p.m. – 3:05 p.m.

T35.4 **An Improved High Voltage DC–DC Converter with Partial-Resonant Network for Enhanced Efficiency and Power Density in Electric Vehicle Applications**
Jaehyung Lee, Tae-Won Noh, Jung-Hoon Ahn, Byoung Kuk Lee
Sungkyunkwan University, Korea

3:05 p.m. – 3:25 p.m.

T35.5 **Isolated DC-DC Converter Utilizing GaN Power Device for Automotive Application**
Hiroaki Matsumori, Takashi Kosaka, Kisho Sekido, Kitae Kim, Takashi Egawa, Nobuyuki Matsui
Nagoya Institute of Technology, Japan

3:25 p.m. – 3:40 p.m.

Break

3:40 p.m – 4:00 p.m.

T35.6 **Phase-Shifted Full-Bridge DC-DC Converter with High Efficiency and Reduced Output Filter Using Center-Tapped Clamp Circuit**
Cheon-Yong Lim, Jung-Kyu Han, Moo-Hyun Park, Keon-Woo Kim, Gun-Woo Moon
KAIST, Korea

4:00 p.m. – 4:20 p.m.

T35.7 **Zero Voltage Soft-Switching Phase-Shift PWM Controlled Three-Level DC-DC Converter for Railway Auxiliary Electric Power Unit**
Tomokazu Mishima, Yoshinobu Koji
Kobe University, Japan

4:20 p.m. – 4:40 p.m.

T35.8 **Modeling, Design, and Experimental Verification of a WPT Level-3 Wireless Charger with Compact Secondary Coupler**
Omer C. Onar[1], Veda Prakash N. Galigekere[1], Jason L. Pries[1], Gui-Jia Su[1], Shenli Zou[2], Saeed Anwar[3], Jonathan Wilkins[1], Randy Wiles[1], Larry Seiber[1], Cliff White[1]
[1]Oak Ridge National Laboratory, United States; [2]University of Maryland, United States; [3]University of Tennessee, United States

4:40 p.m .– 5:00 p.m.

T35.9 **A Novel Auxiliary Modular Multilevel Inverter for Electric Vehicle Applications**
Ahmed Sheir[2], Mohamed Youssef[2], Mohamed Orabi[1]
[1]Aswan University, Egypt; [2]University of Ontario Institute of Technology, Canada

1:45 p.m. – 5:00 p.m.

T36: Control Applications

ROOM 213D

Control

CHAIRS:

Martin Ordonez, *The University of British Columbia*

Weiming Zhang, *SF Motors*

1:45 p.m. – 2:05 p.m.

T36.1 **Controller Evaluation of Wirelessly Distributed and Enabled Battery Energy Storage System Under Unequal Battery Modules Capacity Values**
Yuan Cao, Jaber Abu Qahouq
University of Alabama, United States

2:05 p.m. – 2:25 p.m.

T36.2 **Using Feedforward Digital Control to Improve the Power Quality of a Three-Channel BCM Boost Converter for PFC Applications**
Robert Ryan[2], John G. Hayes[2], Richard Morrison[1], Diarmuid Hogan[1]
[1]Advanced Energy, Ireland; [2]University College Cork, Ireland

2:25 p.m. – 2:45 p.m.

T36.3 **Single Mode Near Minimum Deviation Controller for Multi-Level Flying Capacitor Converters**
Liangji Lu, Tom Moiannou, Aleksandar Prodić
University of Toronto, Canada

2:45 p.m. – 3:05 p.m.

T36.4 **Fast Detection of Open Circuit Device Faults and Fault Tolerant Operation of Stacked Multilevel Converters**
Parham Hekmati, Ian P. Brown, Z. John Shen
Illinois Institute of Technology, United States

3:05 p.m. – 3:25 p.m.

T36.5 **A Novel Ripple-Coupling Constant on-Time Controlled Buck Converter IC with Highly Digital Charge-Pump Based Error Amplifier**
Jheng-An Juan Lu, Ching-Jan Chen, Cheng-Yang Hong, Chieh-Ju Tsai
National Taiwan University, Taiwan

3:25 p.m. – 3:40 p.m.

Break

3:40 p.m – 4:00 p.m.

T36.6 **Universal Controllers for PWM Converters: a Normalized Approach**
Franco Degioanni, Ignacio Galiano Zurbriggen, Martin Ordonez
University of British Columbia, Canada

4:00 p.m. – 4:20 p.m.

T36.7 **A Nonlinear Control Strategy to Reduce DC Bus Capacitance in Vienna Rectifier**
Dan Tong[2], Xiaoyong Ren[2], Yu Chen[2], Ming Xu[1], Zhenyang Hao[2]
[1]FSP-Powerland Technology Inc., China;
[2]Nanjing University of Aeronautics and Astronautics, China

4:20 p.m. – 4:40 p.m.

T36.8 **MHz Level Digital PFM Controller with Suppressed Time-Delay Within Several Ten Nanoseconds**
Yuki Matsuo, Hirotaka Nonaka, Yoichi Ishizuka, Yuichi Yokoi, Hirotaka Yamashita
Nagasaki University, Japan

4:40 p.m .– 5:00 p.m.

T36.9 **New Digital Control Method for Improving Dynamic Performance of a Quasi-Resonant Flyback Converter**
Chong Wang[1], Shen Xu[1], Limin Yu[1], Qinsong Qian[1], Shengli Lu[1], Weifeng Sun[1], Haisong Li[2]
[1]Southeast University, China; [2]Wuxi Chipown Micro-electronics limited, China

1:45 p.m. – 5:00 p.m.

T37: Faults and Dynamics in Grid-Tied Systems

ROOM 303AB

Power Electronics for Utility Interface

CHAIRS:

Majid Pahlevani, *University of Calgary*

Xiaoqing Song, *ABB. Inc*

1:45 p.m. – 2:05 p.m.

T37.1 **Open-Circuit Failure Detection and Localization of Full-Bridge Submodules for MMCs with Single Ring Theorem**
Weihao Zhou[2], Heya Yang[2], Min Chen[2], Wuhua Li[2], Xiangning He[2], Junfei Han[1]
[1]Inner Mongolia Electric Power Research Institute, China;
[2]Zhejiang University, China

2:05 p.m. – 2:25 p.m.

T37.2 **Novel Circuit and Method for Fault Reconfiguration in Cascaded H-Bridge Multilevel Inverters**
Haider Mhiesan, Roy McCann, Chris Farnell, H. Alan Mantooth
University of Arkansas, United States

2:25 p.m. – 2:45 p.m.

T37.3 **An Asymmetrical Fault Current Calculation Method of Synchronverter**
Lili He[1], Wen Huang[1], Zhikang Shuai[1], Z. John Shen[2]
[1]Hunan University, China; [2]Illinois Institute of Technology, United States

2:45 p.m. – 3:05 p.m.

T37.4 **Flexible and Fault Tolerant Distributed Control Structures for Modular Power Electronic Transformers**
Mariam Saeed, Alberto Rodríguez, Manuel Arias, Fernando Briz
University of Oviedo, Spain

3:05 p.m. – 3:25 p.m.

T37.5 **Analysis of the Modular Multilevel Converter Under Single Open-Circuit Fault in the Upper Active Switch of a Submodule**
Qichen Yang, Maryam Saeedifard
Georgia Institute of Technology, United States

3:25 p.m. – 3:40 p.m.

Break

3:40 p.m – 4:00 p.m.

T37.6 **Improving Transient Response of VSG Controlled Grid-Tied Converter**
Yawei Wang, Bangyin Liu, Shanxu Duan
Huazhong University of Science and Technology, China

4:00 p.m. – 4:20 p.m.

T37.7 **Unified Grid Integration Algorithm for Synchronization and Power Control of Doubly-Fed Induction Generator**
Ramu Nair, Gopalaratnam Narayanan
Indian Institute of Science Bangalore, India

4:20 p.m. – 4:40 p.m.

T37.8 **Power Balance of Shunt Active Power Filter Based on Voltage Detection: a Harmonic Power Recycler Device**
Rodrigo Guzman Iturra[2], Marvin Cruse[2], Katharina Mütze[1], Peter Thiemann[2], Christian Dresel[1]
[1]Condensator Dominit GmbH, Germany;
[2]South Westphalia University of Applied Sciences, Germany

4:40 p.m .– 5:00 p.m.

T37.9 **A Nonlinear Adaptive Control System for Ups Systems**
Fatemeh Mardani[2], Nicholas Falconar[2], Nabil Akel[1], Rahul Khandekar[1], Victor Goncalves[1], Majid Pahlevani[2]
[1]Alpha Technologies Ltd., Canada; [2]University of Calgary, Canada

1:45 p.m. – 5:00 p.m.

T38: Motor Drive Modulation & Control Strategies

ROOM 303CD

Motor Drives and Inverters

CHAIRS:

Rakibul Islam, *Dura Automotive Systems*

Zhang Zhe, *Nexteer Automotive*

1:45 p.m. – 2:05 p.m.

T38.1 **PMSM Current Management with Overcurrent Regulation**
Haibo Li, Yi Qian, Sohrab Asgarpoor, Justin Bradley
University of Nebraska-Lincoln, United States

2:05 p.m. – 2:25 p.m.

T38.2 **Finite Set Predictive Torque Control Based on Sub-Divided Voltage Vectors of PMSM with Deadbeat Control and Discrete Space Vector Modulation**
Ibrahim Mohd Alsofyani, Seok-Min Kim, Kyo-Beum Lee
Ajou University, Yemen; Ajou University, Korea

2:25 p.m. – 2:45 p.m.

T38.3 **Novel SVPWM Based Switching Sequences for Modular Multilevel DC to AC Converter**
Balanthi Mogru Abdul Beig[2], Majid Poshtan[1], Saikrishna Kanukollu[2]
[1]California Polytechnic State University, United States; [2]Khalifa University of Science and Technology, U.A.E.

2:45 p.m. – 3:05 p.m.

T38.4 **A Unified Modulation Strategy Based on Current Prediction Control for Open-Winding PMSM with Four Bridge Arms**
Wei Hu, Chenhui Ruan, Heng Nian, Dan Sun
Zhejiang University, China

3:05 p.m. – 3:25 p.m.

T38.5 **Voltage Redistribution-Based Anti-Windup Scheme for Induction Motor Current Controller in the Field-Weakening Region**
Bo Wang, Xu Zhang, Yong Yu, Jing Zhang, Hongye Cai, Dianguo Xu
Harbin Institute of Technology, China

3:25 p.m. – 3:40 p.m.

Break

3:40 p.m – 4:00 p.m.

T38.6 **Sinusoidal Voltage Output Inverter for Motor Drives Using Discontinuous Current Mode Operation**
Hiroaki Toyoda, Minami Terada, Ryuji Iijima, Takanori Isobe, Hiroshi Tadano
University of Tsukuba, Japan

4:00 p.m. – 4:20 p.m.

T38.7 **Model Predictive Control of Five-Phase Permanent Magnet Assisted Synchronous Reluctance Motor**
Shamini Dharmasena, Seungdeog Choi
University of Akron, United States

4:20 p.m. – 4:40 p.m.

T38.8 **Model Predictive Current Control for a PMSM Fed by an Indirect Matrix Converter with Torque Ripple Reduction**
Keon Young Kim, Yeongsu Bak, Kyo-Beum Lee
Ajou University, Korea

4:40 p.m .– 5:00 p.m.

T38.9 **A Hybrid PWM Modulation for EMI Filter Size Reduction in a 10 kW GaN-Based Three Phase Inverter**
Yousef Abdullah[2], Will Perdikakis[2], He Li[2], Ke Wang[2], Yue Zhang[2], Xiaodan Wang[2], Jin Wang[2], Liming Liu[1], Sandeep Bala[1]
[1]ABB Inc., United States; [2]Ohio State University, United States

1:45 p.m. – 5:00 p.m.

T39: Power Converter Design for Renewable Energy Applications

ROOM 304AB

Renewable Energy Systems

CHAIRS:

Ashish Kumar, *Texas Instruments*

Yinglai Xia, *Texas Instruments*

1:45 p.m. – 2:05 p.m.

T39.1 **New Surface Mount SiC MOSFETs Enable High Efficiency High Power Density Bi-Directional on-Board Charger with Flexible DC-Link Voltage**
Chen Wei, Jianwen Shao, Binod Agrawal, Dongfeng Zhu, Haitao Xie
Cree Inc., United States; Cree Inc., India; Cree Inc., China

2:05 p.m. – 2:25 p.m.

T39.2 **Analysis and Design of Three Phase Single Stage Isolated Flyback Based PFC Converter with a Novel Clamping Circuit**
Sivanagaraju Gangavarapu, Akshay Kumar Rathore
Concordia University, Canada

2:25 p.m. – 2:45 p.m.

T39.3 **Single-Phase Quasi-Z-Source Inverters: Switching Loss Reduction Using a Quasi-Sinusoidal Modulation Strategy**
Ahmed Abdelhakim[2], Frede Blaabjerg[1], Paolo Mattavelli[2]
[1]Aalborg University, Denmark; [2]University of Padova, Italy

2:45 p.m. – 3:05 p.m.

T39.4 **Isolated AC-DC Interleaved Converter for MVDC Collection Grid in HVDC Offshore Wind Farm**
Marcus Bezerra[2], Jorge L. Wattes Oliveira Jr.[1], Paulo Peixoto Praça[2], Demercil de Souza Oliveira Jr.[2], Luiz Henrique Silva Barreto[3], Bruno R. de Almeida[4]
[1]Federal Institute of Ceará, Brazil; [2]Federal University of Ceará, Brazil; [3]Universidade Federal do Ceará, Brazil; [4]University of Fortaleza, Brazil

3:05 p.m. – 3:25 p.m.

T39.5 **A Notch Prefilter for Three-Phase PLL Under Adverse Grid Conditions**
Jinbo Li, Qin Wang, Peng He, Lan Xiao, Ling Mao
Nanjing University of Aeronautics and Astronautics, China

3:25 p.m. – 3:40 p.m.

Break

3:40 p.m – 4:00 p.m.

T39.6 **An Improved Modulation Strategy for the Active Voltage Clamping HERIC Inverter**
Hui Wang[2], Zhenxi Wu[2], Zhongting Tang[2], Hua Han[2], Yongheng Yang[1], Frede Blaabjerg[1]
[1]Aalborg University, Denmark; [2]Central South University, China

4:00 p.m. – 4:20 p.m.

T39.7 **A New Modulation Strategy to Operate Bidirectional Resonant Converter Under Extended Input Range**
Changkyu Bai[3], Byeongcheol Han[4], Sooa Kim[3], Sung-Ho Lee[2], Minsung Kim[1]
[1]Dongguk University, Korea; [2]Korea Atomic Energy Research Institute, Korea; [3]Pohang University of Science and Technology, Korea; [4]Virginia Polytechnic Institute and State University, Korea

4:20 p.m. – 4:40 p.m.

T39.8 **DC Voltage Control Architecture in Renewable Energy Based Three-Level Converters**
Emanuel Serban[1], Cosmin Pondiche[1], Helmine Serban[2], Cristian Lascu[3], Octavian Cornea[3]
[1]Schneider Electric, Canada; [2]Simon Fraser University, Canada; [3]University Politehnica of Timisoara, Romania

4:40 p.m .– 5:00 p.m.

T39.9 **Impact of Background Harmonic on Filter Capacitor Reliability in Wind Turbine**
Dao Zhou, Yipeng Song, Frede Blaabjerg
Aalborg University, Denmark

1:45 p.m. – 5:00 p.m.

T40: Industrial Applications

ROOM 304CD

Power Electronics Applications

CHAIRS:

Jesus Acero, *University of Zaragoza*

Sombuddha Chakraborty, *TI*

1:45 p.m. – 2:05 p.m.

T40.1 **Digital Current Control of Electric Arc Furnace by Parallel Modular Three-Phase IGBT Inverters**
Sandro Calligaro[1], Roberto Petrella[2]
[1]Free University of Bolzano, Italy; [2]University of Udine, Italy

2:05 p.m. – 2:25 p.m.

T40.2 **An Analysis of Electromagnetic Forces on Cooking Vessels Used in Domestic Induction Heating Appliances Oriented to Identify the Properties of Materials**
Jesus Acero[2], Claudio Carretero[2], Ignacio Lope[1], Jose Miguel Burdío[2]
[1]BSH-Home Appliances, Spain; [2]Universidad de Zaragoza, Spain

2:25 p.m. – 2:45 p.m.

T40.3 **An Assessment of a Square-Wave Series Voltage Compensator Increasing Power Quality on Industrial Electronic Loads Compensating Voltage Sag and Swell**
Marcos Paulo Brito Gomes[2], Igor Amariz Pires[4], Sidelmo Magalhães Silva[2], Braz J. Cardoso Filho[4], Alysson Machado[2], José Ronaldo Silveira Junior[2], Alex-Sander Amável Luiz[1], Samir Duarte Machado[3]
[1]Centro Federal de Educação Tecnológica de Minas Gerais, Brazil; [2]Federal University of Minas Gerais, Brazil; [3]Universidade Federal de Itajubá, Brazil; [4]Universidade Federal de Minas Gerais, Brazil

2:45 p.m. – 3:05 p.m.

T40.4 **Ensemble Machine Learning Based Adaptive Arc Fault Detection for DC Distribution Systems**
Vu Le, Xiu Yao
University at Buffalo, United States

3:05 p.m. – 3:25 p.m.

T40.5 **Active Common-Mode Voltage Cancelation Using Fourth-Leg of Three-Level NPC Converter Based on IGBT for High Voltage Operation**
Jun-Hyung Jung, Seon-Ik Hwang, Jang-Mok Kim
Pusan national university, Korea

3:25 p.m. – 3:40 p.m.

Break

3:40 p.m – 4:00 p.m.

T40.6 **A Regulated 48V-to-1V/100A 90.9%-Efficient Hybrid Converter for PoI Applications in Data Centers and Telecommunication Systems**
Ratul Das, Hanh-Phuc Le
University of Colorado Boulder, United States

4:00 p.m. – 4:20 p.m.

T40.7 **Current Spike Suppression Techniques for Magnetic Bearing Amplifier**
Hsin-Che Hsieh[3], Cheng-Wei Chen[3], Ming-Cheng Chen[2], Jih-Sheng Jason Lai[3], Jin-Mu Lin[1]
[1]Industrial Technology Research Institute, Taiwan; [2]National Taiwan University of Science and Technology, Taiwan; [3]Virginia Polytechnic Institute and State University, United States

4:20 p.m. – 4:40 p.m.

T40.8 **Low-Power Photovoltaic Energy Harvesting with Parallel Differential Power Processing Using a SEPIC**
F. Selin Bagci[3], Yu-Chen Liu[1], Katherine A. Kim[2]
[1]National Ilan University, Taiwan; [2]National Taiwan University, Taiwan; [3]National Taiwan University of Science and Technology, Taiwan

4:40 p.m .– 5:00 p.m.

T40.9 **Identifying Deteriorated or Contaminated Power System Components from RF Emissions**
Kyungin Nam[2], Mohammad Arifur Rahman[2], Jose Alexis De Abreu-Garcia[2], Robert Veillette[2], Michael French[2], Yilmaz Sozer[2], John Lauletta[1]
[1]Exacter, Inc., United States; [2]University of Akron, United States

DIALOGUE SESSIONS

Dialogue Session papers have been selected through the same rigorous peer-review process as papers in the oral technical sessions. They are represented by papers in the APEC Proceedings. In the Dialogue Session, you will have the opportunity to talk at length with the authors about their work, something that is not possible in oral technical sessions. For the Dialogues Session floor plan, see page 87.

11:15 a.m. – 1:45 p.m.

D01: AC-DC Converters

AC-DC Converters

CHAIRS:

Suzan Eren, *Queen's University*

Srdjan Lukic, *NC State University*

D01.1 **A Boost-Full-Bridge-Type Single-Active-Bridge Isolated AC-DC Converter**
Yitong Li[1], Adrià Junyent-Ferré[1], Paul Judge[2]
[1]Imperial College London, United Kingdom; [2]University of Edinburgh, United Kingdom

D01.2 **6.6kW Three-Phase Interleaved Totem Pole PFC Design with 98.9% Peak Efficiency for HEV/EV Onboard Charger**
Xun Gong, Gangyao Wang, Manish Bhardwaj
Texas Instruments Inc., United States; Texas Instruments Inc., Germany

D01.3 **A Single-Phase Single-Stage Three-Level AC/DC Resonant Converter Operating with a Wide Output Voltage Range**
Eunsoo Kim, Takongmo Marius, Minji Kim, Jaesung Oh, Gangwoo Lee, Ingab Hwang
Jeonju University, Korea

D01.4 **Analysis and Design of an Interleaved Single-Stage ZVS AC-DC Boost Converter**
Adel Ali Abosnina, Gerry Moschopoulos
Western University, Canada

D01.5 **An AC-DC Interleaved ZCS-PWM Boost Converter with Improved Light-Load Efficiency**
Ramtin Rasoulinezhad, Adel Ali Abosnina, Gerry Moschopoulos
Western University, Canada

D01.6 **Power Adapter with Line Voltage Control for USB Power Delivery**
Yang Chen, Yan-Fei Liu
Queen's University, Canada

D01.7 **Single Power-Conversion AC-DC Converter Using Active-Clamp Circuit with Noncomplementary Modulation Strategy**
Seo-Gwang Jeong[2], Kwang-Seop Kim[2], Jun-Seok Kim[2], Owon Kwon[2], Hwasoo Seok[2], Minsung Kim[1], Bong-Hwan Kwon[2]
[1]Dongguk University, Korea; [2]Pohang University of Science and Technology, Korea

D01.8 **An Improved Power-Decoupling Scheme with Grid Inductor Phase-Shift Modification for Single-Phase Converter**
Xiaoqing Wang, Lei Jing, Bodong Li, Ning Chen, Maohang Qiu, Min Chen
Zhejiang University, China

D01.9 **A Novel Multiplexed Power Architecture for Improving Cross Regulation and Efficiency**
Adrian Lefedjiev Lefedjiev
Power Integrations, United States

D01.10 **99% Efficiency 3-Level Bridgeless Totem-Pole PFC Implementation with Low-Voltage Silicon at Low Cost**
Trong Tue Vu, Edgaras Mickus
ICERGi Ltd., Ireland

D01.11 **Multiphase X-Type Current Source Rectifier with Reduced Active Switch Count**
Louelson Costa[1], Montie Vitorino[1], Mauricio Corrêa[1], Dushan Boroyevich[2]
[1]Federal University of Campina Grande, Brazil; [2]Virginia Polytechnic Institute and State University, United States

D01.12 **Control Scheme Design for Isolated Swiss-Rectifier Based on Phase-Shifted Full-Bridge Topology**
Binfeng Zhang, Shaojun Xie, Xincheng Wang, Qiang Qian, Zhao Zhang, Jinming Xu
Nanjing University of Aeronautics and Astronautics, China

D01.13 **Variable on-Time (VOT) Control with Phase Leading Input Current (PLIC) Compensation for 400Hz CRM Boost PFC Converters**
Yuting Zhou, Xiaoyong Ren, Zhehui Guo, Yu Wu, Zhiliang Zhang, Qianhong Chen
Nanjing University of Aeronautics and Astronautics, China

11:15 a.m. – 1:45 p.m.

D02: DC-DC Converters I

DC-DC Converters

CHAIRS:

Brad Lehman, *Northeastern University*

Tirthajyoti Sarkar, *Onsemi*

D02.1 **Multiport Soft-Switching Bidirectional DC-DC Converter for Hybrid Energy Storage Systems**
Satyaki Mukherjee[2], Debranjan Mukherjee[1], Debaprasad Kastha[1]
[1]Indian Institute of Technology Kharagpur, India; [2]University of Colorado Boulder, United States

D02.2 **A Two-Stage Rail Grade DC/DC Converter Based on GaN Device**
Minfan Fu[1], Chao Fei[2], Yuchen Yang[2], Qiang Li[2], Fred C. Lee[2]
[1]ShanghaiTech University, China; [2]Virginia Polytechnic Institute and State University, United States

D02.3 **Symmetrical Voltage Balancing Control for Four-Level Flying Capacitor Converter Based on Phase-Shifted PWM**
Che-Yu Lu[2], Hung-Chi Chen[2], Chung-Yi Li[1]
[1]Chang Gung University, Taiwan; [2]National Chiao Tung University, Taiwan

D02.4 **A Single-Switched High-Switching-Frequency Quasi-Resonant Flyback Converter with Zero-Current-Switching and Valley-Switching**
Shen Xu[1], Chong Wang[1], Qinsong Qian[1], Jing Zhu[1], Weifeng Sun[1], Haisong Li[2]
[1]Southeast University, China; [2]Wuxi Chipown Micro-electronics limited, China

D02.5 **A Study on a Three-Level Flying Capacitor Boost Converter with an Integrated LC2D Output Network for Universal Input Voltage Applications**
Nour Elsayad, Hadi Moradisizkoohi, Osama Mohammed
Florida International University, United States

D02.6 **An Analysis of Operation in Single-Switch High Step-Up DC-DC Converter with Three-Winding Coupled Inductor**
Masataka Minami, Kosuke Tomoeda
Kobe City College of Technology, Japan

D02.7 **Open-Loop Power Sharing of Three-Port DC-DC Resonant Converters**
Yan-Kim Tran, Francisco D. Freijedo, Drazen Dujic
École Polytechnique Fédérale de Lausanne, Switzerland

D02.8 **New Non-Isolated Interleaved Bidirectional Soft-Switching DC-DC Converter with a Low Current Stress and Low Voltage Stress Auxiliary Cell**
Lejia Sun[1], Fang Zhuo[1], Lei Feng[1], Chengzhi Zhu[2]
[1]Xi'an Jiaotong University, China; [2]Zhejiang Electric Power Corporation, China

D02.9 **A Step-Up Series-Parallel Resonant Switched-Capacitor Converter with Extended Line Regulation Range**
Wenhao Xie[2], Shouxiang Li[1], Yifei Zheng[3], Keyue Smedley[3], Jianze Wang[2], Yanchao Ji[2], Jilai Yu[2]
[1]Beijing Institute of Technology, China; [2]Harbin Institute of Technology, China; [3]University of California, Irvine, United States

D02.10 **A Novel Noncomplementary Active Clamp Flyback Control Technique**
Alberto Bianco[1], Claudio Adragna[1], Stefano Saggini[2], Mario Ursino[2], Francesco Ciappa[1], Giuseppe Scappatura[1]
[1]STMicroelectronics, Italy; [2]University of Udine, Italy

D02.11 **Auxiliary Resonant Source Charge Extraction Circuitry for Enabling the Use of Super Junction MOSFETs in High Efficiency DC-DC Converters**
Andrew Hopkins[1], Nick Simpson[1], Neville McNeill[2]
[1]University of Bristol, United Kingdom; [2]University of Strathclyde, United Kingdom

D02.12 **Capacitor Voltage Balancing Control for 3LNPC LLC Resonant Converter**
Yu Qi[1], Tao Chen[1], Wenqing Mei[1], Zhixue Zhang[1], Zedong Zheng[2], Wenguang Luo[1], Liangliang Su[1]
[1]CRRC Zhuzhou Institute Co. Ltd., China; [2]Tsinghua University, China

D02.13 **Ultra-High Step-Up DC/DC Converter Based on Dual-Coupled-Inductors with Low Voltage Stress and Input Current Ripple for Renewable Energy Applications**
Hadi Moradisizkoohi, Nour Elsayad, Osama Mohammed
Florida International University, United States

D02.14 **Resonant Switched-Capacitor Converter with Multi-Resonant Frequencies**
Owen Jong, Qiang Li, Fred C. Lee
Virginia Polytechnic Institute and State University, United States

D02.15 **A Non-Isolated High Step-Up Hybrid Resonant Converter Based on Hybrid Transformer**
Wenhao Xie[2], Yifei Zheng[3], Shouxiang Li[1], Jianze Wang[2], Yanchao Ji[2], Jilai Yu[2]
[1]Beijing Institute of Technology, China; [2]Harbin Institute of Technology, China; [3]University of California, Irvine, United States

D02.16 **12 Switch Zero-Inductor Voltage Converter Topology**
Samuel Webb, Yan-Fei Liu
Queen's University, Canada

D02.17 **Fast Transient Current Control for Dual-Active-Bridge DC-DC Converters with Triple-Phase-Shift**
Jinghui Xu[3], Yue Wang[3], Kai Li[3], Xiufang Hu[3], Shiyuan Yin[3], Rui Li[1], Chunhui Lv[2]
[1]China Electric Power Research Institute, China; [2]Liaocheng Power Supply Company State Grid Shandong Electric Power Company, China; [3]Xi'an Jiaotong University, China

D02.18 **Enhancing Inherent Flux Balancing in a Dual-Active Bridge Using Adaptive Modulation**
Christian Winter[1], Jan Riedel[2], Zaki Mohzani[2], Raphael Mencher[2], Stefan Butzmann[1]
[1]Bergische Universität Wuppertal, Germany; [2]Robert Bosch GmbH, Germany

D02.19 **Design and Optimization of a Wide Dynamic Range Programmable Power Supply for Data Center Applications**
Reto Christen[1], Jasmin Smajic[1], Arvind Sridhar[2], Thomas Brunschwiler[2]
[1]HSR University of Applied Sciences of Eastern Switzerland, Switzerland; [2]IBM Research - Zürich, Switzerland

11:15 a.m. – 1:45 p.m.

D03: DC-DC Converters II

DC-DC Converters

CHAIRS:

Yuxiang Shi, *ABB*

Jaehoon Baek, *Korea University of Technology & Education*

D03.1 **A Dickson Resonant Switched-Capacitor Converter with "Indirect" Resonant Core and Continuous Conversion Ratio**
Shouxiang Li[1], Ningning Zhang[1], Shuhua Zheng[1], Wenhao Xie[2], Keyue Smedley[3]
[1]Beijing Institute of Technology, China; [2]Harbin Institute of Technology, China; [3]University of California, Irvine, United States

D03.2 **Current Sharing Control of Interleaved LLC Resonant Converter with Hybrid Rectifier**
Jiaxiang Sun[1], Xinxi Tang[1], Yan Xing[1], Baolin Chen[1], Hongfei Wu[1], Kai Sun[2]
[1]Nanjing University of Aeronautics and Astronautics, China; [2]Tsinghua University, China

D03.3 **LLC DC-DC Converter with Flyback-Operation for Expanding the Regulation Range**
Hiroki Nakashima[1], Hisatsugu Kato[2], Yohei Araki[1], Yoichi Ishizuka[1]
[1]Nagasaki University, Japan; [2]Tabuchi Electric Co., Ltd., Japan

D03.4 **Pareto Design and Switching Frequencies for SiC MOSFETs Applied in an 11kW Buck Converter for EV-Charging**
Benjamin Strothmann, Frank Schafmeister, Joachim Böcker
Universität Paderborn, Germany

D03.5 **A High-Speed, Non-Linear Control Based Voltage Droop Mitigation Technique for Integrated Voltage Regulators in Modern Microprocessors**
Sivaraman Masilamani, Arvind Raghavan, Ravi Sankar Vunnam, Sarath Makala
Intel Corporation, United States

D03.6 **Parasitic Parameter Effects on the dv/dt-Induced Low-Side MOSFET False Turn-on in Synchronous Buck Converters**
Ruqi Li[1], Joyce Zhu[1], Manjing Xie[2]
[1]Cisco Inc., United States; [2]Texas Instruments Inc., United States

D03.7 **A Two-Phase Zero-Inductor Voltage Converter for Datacenter and Server Applications**
Samuel Webb, Yan-Fei Liu, Tianshu Liu
Queen's University, Canada

D03.8 **High-Speed ZVS-ZCS Soft-Switching CMOS Bridge Drivers for a DC-DC Fully Integrated Voltage Regulator (FIVR) Operating at 100-320MHz on 22nm Process Node**
Gerhard Schrom, Ravi Sankar Vunnam, Sarath Makala, Alexander Lyakhov
Intel Corporation, United States

D03.9 **A New Bidirectional High Frequency AC-Link Microinverter Based on Dual Active Bridge Topology**
Amit Bhattacharjee, Issa Batarseh
University of Central Florida, United States

D03.10 **A Cuk Dual Resonance Core Based Dickson Resonant Switched-Capacitor Converter with Wide Conversion Ratio Range**
Shouxiang Li[1], Shengnan Liang[1], Shuhua Zheng[1], Wenhao Xie[2], Keyue Smedley[3]
[1]Beijing Institute of Technology, China; [2]Harbin Institute of Technology, China; [3]University of California, Irvine, United States

D03.11 **A Novel Dual Output Dual-Active-Bridge Converter with Output Voltage Balancing**
Kisu Kim, Jeonghun Kim, Honnyong Cha, Sanghun Kim
Kyungpook National University, Korea

D03.12 **Practical Comparison of ZVZCS Interleaved Boost Converters with SiC Devices**
Md Rishad Ahmed[1], Yun Li[1], Rebecca Todd[2], Andrew Forsyth[2]
[1]CRRC Times Electric UK Innovation Centre, United Kingdom; [2]University of Manchester, United Kingdom

D03.13 **Research on Current Sharing Strategy of Parallel LLC Resonant Converter**
Yakun Wang, Xiaoyong Ren, Zhiliang Zhang, Qianhong Chen
Nanjing University of Aeronautics and Astronautics, China

D03.14 **A 3-Bridge LLC Resonant Converter Operating with a Wide Output Voltage Control Range Using Morphing Control for Mode Transitions**
Jaesung Oh[1], Jicheol Lee[1], Minji Kim[1], Sangjae Yoo[1], Eunsoo Kim[1], Yongseog Jeon[1], Yoonsang Kook[2]
[1]Jeonju University, Korea; [2]PACTECH Co., LTD, Korea

D03.15 **High-Step-Up Boost Converter Based on Coupled Inductor, Voltage Lift and Clamp Cells**
G. A. K. Somiruwan[2], L.H.P.N. Gunawardena[2], Dulika Nayanasiri[1], Yun Wei Li[1]
[1]University of Alberta, Canada; [2]University of Moratuwa, Sri Lanka

D03.16 **A Variable Frequency ZVS Control of a Three-Level Buck Without Zero Crossing Detection for Wide-Range Output Voltage Battery Chargers**
Bo Liu[2], Ren Ren[2], Fred Wang[2], Daniel J. Costinett[2], Zheyu Zhang[1]
[1]GE Global Research, United States; [2]University of Tennessee, United States

D03.17 **A PWM Controlled Active Boost Quadrupler Resonant Converter for High Step-Up Application**
Cheng-Wei Chen, Xiaonan Zhao, Jih-Sheng Jason Lai
Virginia Polytechnic Institute and State University, United States

D03.18 **A New Non-Multi-Level Structured, H-Bridgeless DC/DC Bidirectional Converter with Low Voltage Stress and Complete Soft-Switching Operation**
Reza Emamalipour, John Lam
York University, Canada

D03.19 **1-kV Input 1-MHz GaN Modular Multilevel LLC Converters**
Ke Xu, Zhiliang Zhang, Zhi-Wei Xu, Ming-Xie He, Haoran Li, Xiaoyong Ren, Qianhong Chen
Nanjing University of Aeronautics and Astronautics, China

D03.20 **1-kV Input 300-Khz SiC LLC Converters with Matrix Transformers**
Zhi-Wei Xu, Zhiliang Zhang, Haoran Li, Ming-Xie He, Jia-Cheng Tang, Ke Xu, Xiaoyong Ren, Qianhong Chen
Nanjing University of Aeronautics and Astronautics, China

D03.21 **Dual-Loop Control for Synchronous-Conduction-Mode Tapped-Inductor Buck Converter**
Chih-Shen Yeh[2], Xiaonan Zhao[2], Ming-Cheng Chen[1], Jih-Sheng Jason Lai[2]
[1]National Taiwan University of Science and Technology, Taiwan; [2]Virginia Polytechnic Institute and State University, United States

D03.22 **A 1-MHz GaN Converter with 4X Voltage Range**
Ming-Xie He, Xinyi Zhu, Zhiliang Zhang, Xiaoyong Ren
Nanjing University of Aeronautics and Astronautics, China

11:15 a.m. – 1:45 a.m.

D04: Utility Interactive Converters II

Power Electronics for Utility Interface

CHAIRS:

Jonathan Kimball, *Missouri University of Science and Technology*

Pritam Das, *Binghampton University*

D04.1 **A Statistical Submodule Open-Circuit Failure Diagnosis Method for MMCs Enabling Failure Detection, Localization and Classification**
Weihao Zhou[2], Heya Yang[2], Huan Yang[2], Min Chen[2], Wuhua Li[2], Xiangning He[2], Junfei Han[1]
[1]Inner Mongolia Electric Power Research Institute, China; [2]Zhejiang University, China

D04.2 **Research on Large Current Interruption of Solid-State Switch for a Hybrid DCCB**
Lei Feng[1], Ruifeng Gou[2], Xiaoping Yang[2], Fang Zhuo[1], Feng Wang[1]
[1]Xi'an Jiaotong University, China; [2]Xi'an XD Power Systems Co,. Ltd., China

D04.3 **An Embedded Switched-Capacitor Z-Source Inverter with Continuous Input Currents**
Jing Yuan[1], Yongheng Yang[1], Ping Liu[2], Yanfeng Shen[1], Frede Blaabjerg[1]
[1]Aalborg University, Denmark; [2]Hunan University, China

D04.4 **A Simple Technique for in-Circuit Core Loss Measurement of Medium Frequency Transformer**
Zhengda Zhang, Lei Zhang, Jiangchao Qin
Arizona State University, United States

D04.5 **Single Pulse Common-Mode Voltage PWM Scheme to Achieve High Power-Density for Full-SiC Three-Level Uninterruptible Power Supply**
Sungjae Ohn[2], Jianghui Yu[2], Rolando Burgos[2], Dushan Boroyevich[2], Harish Suryanarayana[1], Christopher Belcastro[1]
[1]ABB Inc., United States; [2]Virginia Polytechnic Institute and State University, United States

D04.6 **Series AC Arc Fault Detection Using Only Voltage Waveforms**
Jonathan Kim[2], Dorin Neac u[2], Brad Lehman[2], Roy Ball[1]
[1]MERSEN USA Newburyport-MA, LLC, United States; [2]Northeastern University, United States

D04.7 **EMI Evaluation and Filter Design of a SiC-Based 3-Level Ups**
Jianghui Yu[2], Sungjae Ohn[2], Rolando Burgos[2], Bingyao Sun[2], Dushan Boroyevich[2], Harish Suryanarayana[1], Christopher Belcastro[1]
[1]ABB Inc., United States; [2]Virginia Polytechnic Institute and State University, United States

11:15 a.m. – 1:45 a.m.

D05: Utility Interactive Converters I

Power Electronics for Utility Interface

CHAIRS:

Po-Tai Cheng, *National Tsing Hua University (Taiwan)*

Ali Khajehoddin, *University of Alberta*

D05.1 **Generalized Space Vector Modulation for Grid-Connected Current Source Converter in Both Continuous and Discontinuous Current Modes**
Xiaoqiang Guo, Yong Yang, Baocheng Wang, Zhigang Lu
Yanshan University, China

D05.2 **Stability Analysis and Improvement of Three-Phase Grid-Connected Power Converters with Virtual Inertia Control**
Jingyang Fang[2], Pengfeng Lin[2], Hongchang Li[2], Yi Tang[2], Yongheng Yang[1]
[1]Aalborg University, Denmark; [2]Nanyang Technological University, Singapore

D05.3 **A New Control Strategy for Hybrid Water Pumping Systems Used by Utilities in Developing Countries**
Abbas Gholamshahi[1], Roohollah Fadaeinedjad[1], Ebrahim Mohammadi[1], Gerry Moschopoulos[2]
[1]Graduate University of Advanced Technology, Iran; [2]Western University, Canada

D05.4 **Use of Multiple Transformer Windings for Efficiency Enhancement in the Series Transistor-Array Based Linear AC Voltage Regulator**
Nimesha Priyanwada Wijesooriya, Nihal Kularatna, D. Alistair Steyn-Ross
University of Waikato, New Zealand

D05.5 **A New Multinivel Converter Based on the Use of Interleaving Technique and Cascade Association**
Samuel Soares Queiroz[1], Demercil de Souza Oliveira Jr.[1], Paulo Peixoto Praça[1], Luiz Henrique Silva Barreto[2]
[1]Federal University of Ceará, Brazil; [2]Universidade Federal do Ceará, Brazil

D05.6 **Multiple Second-Order Generalized Integrators Based Comb Filter for Fast Selective Harmonic Extraction**
Chuan Xie[2], Kai Li[2], Jianxiao Zou[2], Keliang Zhou[3], Josep M. Guerrero[1]
[1]Aalborg University, Denmark; [2]University of Electronic Science and Technology of China, China; [3]University of Glasgow, United Kingdom

D05.7 **Design and Analysis of Interleaved Current Fed Switched Inverter**
Sonam Acharya, Santanu K. Mishra
Indian Institute of Technology Kanpur, India

D05.8 **Design Considerations of Tri-Mode Intelligent Solid State Circuit Breaker Using GaN Transistors**
Yuanfeng Zhou, Yanjun Feng, Z. John Shen
Illinois Institute of Technology, United States

D05.9 **Average Current Sharing Control Strategy for Parallel Operation of Ups with Low Bandwidth Communication**
Seunghoon Baek[1], Younghoon Cho[1], Tae-Geun Koo[2]
[1]Konkuk University, Korea; [2]Sungshin Electric Co. Ltd., Korea

D05.10 **Autonomous Control of Active Power Electronics Loads Considering Response Cost in Islanded Microgrid**
Song Zhang[1], Guangqian Ding[2], Yanjie Zhang[1], Gaiyun Huang[1]
[1]State Grid Corporation of China Technology, China; [2]University of Jinan, China

D05.11 **DC Offset Compensation Algorithm in the Grid Voltage of Single-Phase Grid-Connected Inverter**
Tae-Seong Kim[2], Seon-Hwan Hwang[2], Jin-Soo Kim[1], Jong-Won Park[1]
[1]GMB Korea, Korea; [2]Kyungnam University, Korea

11:15 a.m. – 1:45 p.m.

D06: Inverters

Motor Drives and Inverters

CHAIRS:

Poria Fajri, *University of Nevada, Reno*

Mehdi Farasat, *Louisiana State University*

D06.1 **A Novel DC-Link Voltage Control for Small-Scale Grid-Connected Wind Energy Conversion System**
Guanhong Song, Bo Cao, Liuchen Chang, Riming Shao, Shuang Xu
University of New Brunswick, Canada

D06.2 **A High-Efficiency Super-Junction MOSFET Based Inverter-Leg Configuration Using a Dual-Mode Switching Technique**
Zhengyang Feng, Neville McNeill, Barry Williams
University of Strathclyde, United Kingdom

D06.3 **Optimization of the Modulation Sequence and Proposing an Overlap Technique for Current Source Inverter**
Mahmoud Gaber, Omar Abdel-Rahim, Mohamed Orabi
Aswan University, Egypt

D06.4 **Analysis of Circulating Harmonic Currents in Paralleled Three Level ANPC Inverters Using SVM**
Jiahao Niu[2], Ruirui Chen[2], Zheyu Zhang[2], Handong Gui[2], Fred Wang[2], Leon M. Tolbert[2], Benjamin J. Blalock[2], Daniel J. Costinett[2], Benjamin B. Choi[1]
[1]NASA Glenn Research Center, United States; [2]University of Tennessee, United States

D06.5 **Impedance Estimation Using Power Monitoring Feature for Tuning AFE Gains**
Ripunjoy Phukan[2], Lixiang Wei[1], Linglai Li[1], Benfeng Tang[1]
[1]Rockwell Automation Inc., United States; [1]Rockwell Automation Inc., China; [2]Virginia Polytechnic Institute and State University, United States

D06.6 **A Novel Hybrid SVPWM Modulation Algorithm for Five Level Active Neutral-Point-Clamped Converter**
Hui Chen, Yingjie He, Jinjun Liu, Xingxing Chen, Hongwei Xiao, Wenhao Zhi, Ruiqi Cheng
Xi'an Jiaotong University, China

D06.7 **A New Post-Fault Control Method Based on Sinusoidal Pulse Width Modulation Technique for a Neutral Point Clamped (NPC) Inverter**
Peter Azer, Saeed Ounie, Mehdi Narimani
McMaster University, Canada

D06.8 **Interleaved SPWM of Parallel Csc System with Low Common-Mode Voltage**
Li Ding, Yuzhuo Li, Yun Wei Li
University of Alberta, Canada

D06.9 **A New 5–Level Voltage Source Inverter**
Apparao Dekka, Ali Ramezani, Saeed Ounie, Mehdi Narimani
McMaster University, Canada

D06.10 **Cascaded Transformer Multilevel Inverter with Shared Leg Based on Neutral-Point Clamped**
Filipe A. C. Bahia[1], Cursino B. Jacobina[1], Nady Rocha[2], Reuben P. R. Sousa[1], Nayara B. Freitas[1]
[1]University Federal of Campina Grande, Brazil; [2]University Federal of Paraiba, Brazil

D06.11 **Design of a Single Controller for Multiple Paralleled Inverters**
Jiahao Niu[2], Ruirui Chen[2], Zheyu Zhang[2], Handong Gui[2], Fred Wang[2], Leon M. Tolbert[2], Benjamin J. Blalock[2], Daniel J. Costinett[2], Benjamin B. Choi[1]
[1]NASA Glenn Research Center, United States; [2]University of Tennessee, United States

11:15 a.m. – 1:45 p.m.

D07: Motor Drives

Motor Drives and Inverters

CHAIRS:

Sangshin Kwak, *Chung-Ang University*

Rashmi Prasad, *General Motors*

D07.1 **Rotational Frame Fundamental Saliency Method for Position Sensorless Control of Synchronous Reluctance Machines**
Tetsuya Kojima, Toshiki Suzuki, Moriyuki Hazeyama, Shinsuke Kayano
Mitsubishi Electric Corporation, Japan

D07.2 **A High Performance Five-Phase Six-Leg VSI and the Corresponding SVPWM Strategy**
An Li, Dong Jiang, Wubin Kong, Ronghai Qu
Huazhong University of Science and Technology, China

D07.3 **High Frequency Torque Ripple Suppression for High Frequency Signal Injection Based Sensorless Control of SynRMs**
Chengrui Li, Gaolin Wang, Guoqiang Zhang, Dianguo Xu
Harbin Institute of Technology, China

D07.4 **Current Sensor Fault Diagnosis and Fault-Tolerant Control for Encoderless PMSM Drives Based on Dual Sliding-Mode Observers**
Guoqiang Zhang, Gaolin Wang, Honglei Zhou, Chengrui Li, Guoxin Wang, Dianguo Xu
Harbin Institute of Technology, China

D07.5 **Real Time Hardware-in-the-Loop Validation of Common Bus Inverter Low Voltage Drives**
Karthik Palaniappan[2], Brian Seibel[2], Michael Cook[2], Christian Dufour[1]
[1]Opal-RT Technologies Inc., Canada; [2]Rockwell Automation Inc., United States

D07.6 **Model Predictive Control Using Globe Exponential Reaching Law Sliding Mode Design Method for Induction Motor Drives**
Zhonggang Yin, Yanqing Zhang, Xiangqian Tong, Yanru Zhong
Xi'an University of Technology, China

D07.7 **A Finite Control Set Model Predictive Current Control Scheme for Five-Phase PMSMs Based on Optimized Duty Ratio**
Bin Yu, Wensheng Song, Tao Tang, Song Wang, Ping Yang
Southwest Jiaotong University, China

D07.8 **Application of Off-Policy Integral Reinforcement Learning for H∞,Input Constrained Control of Permanent Magnet Synchronous Machine**
Yang Yu[1], Shuai Wang[1], Yudong Du[4], Rong Su[1], Vaiyapuri Viswanathan[2], Shanmukha Ramakrishna[2], Chandana Gajanayake[2], Amit Kumar Gupta[3]
[1]Nanyang Technological University, Singapore; [2]Rolls-Royce, Singapore; [3]Rolls-Royce Singapore Pte Ltd, Singapore; [4]Xi'an Jiaotong University, China

D07.9 **MTPA Control of Sensorless IPMSM Based on High Frequency Square-Wave Signal Injection**
Zhichen Lin[2], Qiang Geng[1], Zhanqing Zhou[1], Xinmin Li[1], Changliang Xia[1]
[1]Tianjin Polytechnic University, China; [2]Tianjin University, China

D07.10 **Investigation of Fourth-Leg for Common-Mode Noise Reduction in Three-Level Neutral Point Clamped Inverter Fed Motor Drive**
Ruirui Chen[2], Jiahao Niu[2], Handong Gui[2], Zheyu Zhang[2], Fred Wang[2], Leon M. Tolbert[2], Benjamin J. Blalock[2], Daniel J. Costinett[2], Benjamin B. Choi[1]
[1]NASA Glenn Research Center, United States; [2]University of Tennessee, United States

D07.11 **Interior Permanent Magnet Synchronous Motor Maximum Torque Per Ampere-Position Sensorless Control**
Shuqi Ling[2], Tingna Shi[3], Zhichen Lin[2], Qiang Geng[1], Changliang Xia[1]
[1]Tianjin Polytechnic University, China; [2]Tianjin University, China; [3]Zhejiang University, China

D07.12 **Power Capability Improvement of Interior Permanent Magnet Synchronous Motor Drives Using Capacitive Network**
Kahyun Lee, Jung-Ik Ha
Seoul National University, Korea

D07.13 **A Novel Configuration of DC Link EMI Filter Capacitors in Variable Frequency Drives**
Xuechao Wang, Lakshmi Ravi, Michael Albert, Rangarajan Tallam
Rockwell Automation Inc., United States

D07.14 **A Sensor Fault Isolation Scheme for Co-Existence of PMSM Current Sensor and Non-Sensor Imbalance Faults**
Haibo Li, Yi Qian, Sohrab Asgarpoor, Hamid Sharif
University of Nebraska-Lincoln, United States

D07.15 **A Compact 50-kW Traction Inverter Design Using Off-the-Shelf Components**
Rana Alizadeh[2], Tyler Adamson[2], Juan Carlos Balda[2], Yue Zhao[2], Mehdi Asheghi[1], Ken Goodson[1]
[1]Stanford University, United States; [2]University of Arkansas, United States

D07.16 **Reliability Improvement of Power Inverters for Low-Speed High-Power Motor Drives**
Yu Zou[3], Sandun Kuruppu[3], Jiangbiao He[1], Bojian Cao[2]
[1]GE Global Research, United States; [2]General Motors, United States; [3]Saginaw Valley State University, United States

D07.17 **High-Speed and High-Dynamic Variable Frequency Drive Using Modular Multilevel Converter and SiC Devices**
Jianyu Pan, Ziwei Ke, Risha Na, Julia Zhang, Longya Xu
Ohio State University, United States

D07.18 **Comprehensive Performance Comparison and Optimization of Single-Pulse Controlled Srgs for Renewable Electrical Grids**
Lefei Ge[2], Bernhard Burkhart[1], Annegret Klein-Hessling[2], Huihui Xu[2], Rik W. De Doncker[2]
[1]ENGIRO GmbH, Germany; [2]RWTH Aachen University, Germany

11:15 a.m. – 1:45 p.m.

D08: Magnetic Components

Devices and Components

CHAIRS:

Edward Herbert, *Inventor*

Kisacikoglu Mithat, *Seoul Tech*

D08.1 **Comparison of Coupled Vs. Non-Coupled Microfabricated Inductors in 2W 20MHz Interleaved Buck Converter**
Youssef Kandeel, Maeve Duffy
National University of Ireland Galway, Ireland

D08.2 **A Passive Integrated Unit of LCL Filter and Transformer for Grid-Connected Inverter**
Cheng Deng[2], Masiqian Yong[2], Andrés Escobar-Mejía[1]
[1]Universidad Tecnológica de Pereira, Colombia; [2]Xiangtan University, China

D08.3 **Hysteresis Compensation Method for Measurement Error of Hall Effect Current Sensor Considering Eddy Current Effect for Electric Vehicle at High Speed**
Kiseok Kim[3], Kichul Hong[3], Heekwang Lee[2], Hyeongsub Kim[1], Sunki Hong[1]
[1]Hoseo University, Korea; [2]Hyundai motor, Korea; [3]ITXM2M Co., Ltd., Korea

D08.4 **Design of a Low-Capacitance Planar Transformer for a 4 kW/500 kHz DAB Converter**
Pierre Demumieux[4], Oriol Avino-Salvado[4], Cyril Buttay[1], Christian Martin[4], Fabien Sixdenier[4], Charles Joubert[4], Jean Sylvio Ngoua Teu Magambo[2], Thomas Löher[3]
[1]Institut National des Sciences Appliquées de Lyon, France; [2]Safran Tech, France; [3]Technische Universität Berlin, Germany; [4]Université Lyon 1, France

D08.5 **Hetero-Magnetic Coupled Inductor (HMCI) for High Frequency Interleaved Multiphase DC/DC Converters**
Shengchang Lu[2], Chao Ding[2], Yunhui Mei[1], Khai Ngo[2], Guoquan Lu[2]
[1]Tianjin University, China; [2]Virginia Polytechnic Institute and State University, United States

D08.6 **Design of CM Inductor Based on Core Loss for Radiated EMI Reduction in Power Converters**
Juntao Yao, Yiming Li, Hui Zhao, Shuo Wang
University of Florida, United States

D08.7 **A Study of Flux Distribution and Impedance in Solid and Laminar Ferrite Cores**
Marcin K cki[2], Marek S. Ryłko[2], John G. Hayes[3], Charles R. Sullivan[1]
[1]Dartmouth College, United States; [2]SMA Magnetics sp. z o.o., Poland; [3]University College Cork, Ireland

D08.8 **Current Balancing for Parallel Connection of Silicon Carbide MOSFETs Using Bus Bar Integrated Magnetic Material**
Kazuki Matsubara, Keiji Wada
Tokyo Metropolitan University, Japan

D08.9 **Design of High-Performance Toroidal DC-Link Inductor for Current-Source Inverters**
Renato Amorim Torres, Hang Dai, Thomas M. Jahns, Bulent Sarlioglu
University of Wisconsin-Madison, United States

11:15 a.m. – 1:45 p.m.

D09: Devices and Components II

Devices and Components

CHAIRS:

Christina Dimarino, *Virginia Tech*

Yam Siwakoti, *University of Technology Sydney*

D09.1 **Online Condition Monitoring of IGBT Modules Using Gate-Charge Identification**
Mohamed Halick Mohamed Sathik[2], Prasanth Sundararajan[2], Firman Sasongko[2], Josep Pou[1], Amit Kumar Gupta[3]
[1]Nanyang Technological University, Singapore; [2]Rolls Royce NTU Corporate lab, Singapore; [3]Rolls-Royce Singapore Pte Ltd, Singapore

D09.2 **Challenges and Strategies for a Real-Time Implementation of a Rainflow-Counting Algorithm for Fatigue Assessment of Power Modules**
Antonios Antonopoulos[1], Magnar Hernes[2], Salvatore D'Arco[2], Dimosthenis Peftitsis[1]
[1]Norwegian University of Science and Technology, Norway; [2]SINTEF Energy Research, Norway

D09.3 **Soft Switching Behavior of IGCT for Resonant Conversion**
Dragan Stamenkovic[2], Umamaheswara Reddy Vemulapati[1], Thomas Stiasny[1], Munaf Rahimo[1], Drazen Dujic[2]
[1]ABB Semiconductors, Switzerland; [2]École Polytechnique Fédérale de Lausanne, Switzerland

D09.4 **Real-Time, in Situ Degradation Monitoring in Power Semiconductor Converters**
Timothy Polom[2], Christoph van der Broeck[1], Rik W. De Doncker[1], Robert Lorenz[2]
[1]RWTH Aachen University, Germany; [2]University of Wisconsin-Madison, United States

D09.5 **Current Measurement Issues of a High Frequency GaN Inverter in the MHz Order for Magnetic Characterization**
Wilmar Martinez, Camilo Suarez
KU Leuven, Belgium

D09.6 **Smart Current Source Gate Driver for Fast Switching and Cross-Talk Suppression of SiC MOSFET**
Chunhui Liu, Qin Lei
Arizona State University, United States

D09.7 **High-Speed Searching of Optimum Switching Pattern for Digital Active Gate Drive Circuit of Full Bridge Inverter Circuit**
Yu Shan Cheng[1], Tomoyuki Mannen[1], Keiji Wada[1], Koutaro Miyazaki[2], Makoto Takamiya[2], Takayasu Sakurai[2]
[1]Tokyo Metropolitan University, Japan; [2]University of Tokyo, Japan

D09.8 **Simplified on-Line Monitoring System of MOSFET on-Resistance Based on a Semi-Empirical Model**
Paolo Magnone, Andrea Petucco, Nicola Thevenet, Hossein Abedini
University of Padova, Italy

D09.9 **Study of the SiC JFET Reverse Conduction and Reverse Blocking Characteristics**
Xiaoqing Song, Yu Du
ABB Inc., United States

D09.10 **Hard-Switching Dynamic Rds,on Characterization of a GaN FET with an Active GaN-Based Clamping Circuit**
Edward Jones, Alejandro Pozo
Efficient Power Conversion Corporation, United States

D09.11 **Series Diode Balancing and Diode Evaluation for High-Voltage High-Frequency Power Converters**
Yiou He, David J. Perreault
Massachusetts Institute of Technology, United States

D09.12 **A Novel Gate Driver for Active Voltage Balancing in 1.7kV Series Connected SiC MOSFETs**
Sanket Parashar, Subhashish Bhattacharya
North Carolina State University, United States

D09.13 **Cascode GaN/SiC Power Device for MHz Switching**
Jiale Xu[1], Lei Gu[1], Zhechi Ye[2], Saleh Kargarrazi[1], Juan Rivas-Davila[1]
[1]Stanford University, United States; [2]Tsinghua University, China

11:15 a.m. – 1:45 p.m.

D10: Power Converter Packaging and Reliability

Power Electronics Integration and Manufacturing

CHAIRS:

Yu Du, *ABB Inc.*

Yuzhi Zhang, *ABB U.S. Corporate Research Center*

D10.1 **Design of a Compact, Low Inductance 1200 V, 6.5 mΩ SiC Half-Bridge Power Module with Flexible PCB Gate Loop Connection**
Grace Watt[2], Amy Romero[2], Rolando Burgos[2], Marko Jaksic[1]
[1]General Motors, United States; [2]Virginia Polytechnic Institute and State University, United States

D10.2 **An in-Depth Analysis of Power-System-in-Inductor (PSI2) Technology for Power Module Packaging**
Andrew Yurek, Wenbo Liu, Yan-Fei Liu
Queen's University, Canada

D10.3 **IoT-Based Degradation Management for Self-Healing Power Converters**
Anderson Vagner Rocha[1], Danilo F. Melo[1], Thales A. Carvalho Maia[2], Victor N. Ferreira[2], Braz J. Cardoso Filho[2]
[1]Centro Federal de Educação Tecnológica de Minas Gerais, Brazil; [2]Universidade Federal de Minas Gerais, Brazil

D10.4 **Design of Printed Circuit Boards for Power Electronics Utilizing Gallium Nitride Ball Grid Array Integrated Half Bridges**
Yashar Naeimi[1], Alex Q. Huang[2]
[1]North Carolina State University, United States; [2]University of Texas at Austin, United States

D10.5 **A 3D Folded Power Inductor with PCB Based Technology for Applications in the kW Range**
Johan Le Leslé[3], Corentin Darbas[3], Florent Morel[2], Nicolas Degrenne[3], Rémy Caillaud[3], Cyril Buttay[1], Roberto Mrad[3], Christian Vollaire[2], Stefan Mollov[3]
[1]Institut National des Sciences Appliquées de Lyon, France; [2]Laboratoire Ampère, France; [3]Mitsubishi Electric R&D Centre Europe, France

D10.6 **Comparison of High Performance Cooling Concepts for SiC Power Modules**
Alexander Sewergin, Alexander Stippich, Arne Hendrik Wienhausen, Rik W. De Doncker
RWTH Aachen University, Germany

D10.7 **Reliability Assessment of Hybrid Capacitor Bank Using Electrolytic- and Film-Capacitors in Three-Level Neutral-Point-Clamped Inverters**
Mengxing Chen, Haoran Wang, Huai Wang, Frede Blaabjerg, Xiongfei Wang, Donghua Pan
Aalborg University, Denmark

D10.8 **Mission Profile-Based Accelerated Testing of DC-Link Capacitors in Photovoltaic Inverters**
Ariya Sangwongwanich[1], Yanfeng Shen[1], Andrii Chub[2], Elizaveta Liivik[2], Dmitri Vinnikov[2], Huai Wang[1], Frede Blaabjerg[1]
[1]Aalborg University, Denmark; [2]Tallinn University of Technology, Estonia

D10.9 **An Experimental Approach to Identify Source and Cause of Radiation Noise of Inverter Systems and Bare Si Power Chips**
Toshiya Tadakuma[1], Michael Rogers[2], Teruaki Nagahara[1]
[1]Mitsubishi Electric Corporation, Japan; [2]Mitsubishi Electric US, INC., United States

D10.10 **Performance Evaluation of a Two-Terminal Active Inductor in the DC-Link Filter of a Three-Phase Diode Bridge Rectifier**
Haoran Wang, Huai Wang
Aalborg University, Denmark

11:15 a.m. – 1:45 p.m.

D11: Modeling and Simulation of Power Converters

Modeling and Simulation

CHAIRS:

Shilpa Marti, *University of Texas at San Antonio*

Babak Parkhideh, *University of North Carolina – Charlotte*

D11.1 **FPGA Resource Optimization Method for Hardware in the Loop Real-Time Simulation of Power Converters**
Jia Qi Yuan, Xizheng Guo, Chenchen Wang, Xiaojie You
Beijing Jiaotong University, China

D11.2 **Solution for Selective Harmonic Elimination in Asymmetric Multilevel Inverter Based on Stochastic Configuration Network and Levenberg-Marquardt Algorithm**
Jun Hao[2], Guoshan Zhang[2], Yuqing Zheng[2], Wei Hu[2], Kehu Yang[1]
[1]China University of Mining and Technology, China; [2]Tainjin University, China

D11.3 **Averaged, Curvature-Based Model of Switched-Capacitor Converters**
Marko Krstic[1], Majid Pahlevani[2], Suzan Eren[1], Praveen Jain[1]
[1]Queen's University, Canada; [2]University of Calgary, Canada

D11.4 **A Four-Level Modular Multilevel Converter with Self Voltage Balancing and Extremely Small DC Capacitor**
Yunting Liu[2], Fang Zheng Peng[1]
[1]Florida State University, United States; [2]Michigan State University, United States

D11.5 **Small-Signal Modeling and Stability Analysis of MMC with the Consideration of Internal Harmonic Interactions**
Shiyuan Yin, Yue Wang, Taiyuan Yin, Zhang Wang, Ronghui An, Pengfan Xu, Cheng Nie, Yongbin Jiang
Xi'an Jiaotong University, China

D11.6 **Discrete-Time Modeling of a Naturally Commutated Current-Fed Dual Active Bridge DC-DC Converter**
Avishek Pal, Santanu Kapat
Indian Institute of Technology Kharagpur, India

D11.7 **State-Space Modeling and Reachability Analysis for a DC Microgrid**
Niloofar Ghanbari[1], Parisa M. Shabestari[2], Ali Mehrizi-Sani[2], Subhashish Bhattacharya[1]
[1]North Carolina State University, United States; [2]Washington State University, United States

D11.8 **Electric-Field Simulation and Application of Detector Installing for ±800kV UHVDC-LCC Converter**
Chenyang Liu, Siquan Hu, Kun Han, Weizheng Yao, Zhanfeng Fan, Qiulin Hu
State Grid Xuji Group Corporation, China

11:15 a.m. – 1:45 p.m.

D12: Power Device and Magnetics Modeling

Modeling and Simulation

CHAIRS:

Hui Li, *Florida State University*

Ruxi Wang, *GE Global Research*

D12.1 **Evaluation of Permanent Magnet Distribution Schemes for Toroid Power Inductor with Increased Saturation Current Using 3D Physical Models**
Zhiyong Xia, Jaber Abu Qahouq, Sushma Kotru
University of Alabama, United States

D12.2 **Topology-Optimization-Based Conductor Pattern Design for Inductance Cancellation Structure to Reduce Common- and Differential-Mode Noise**
Katsuya Nomura[2], Atsuhiro Takahashi[2], Takashi Kojima[2], Shintaro Yamasaki[1], Kentaro Yaji[1], Hiroki Bo[1], Kikuo Fujita[1]
[1]Osaka University, Japan; [2]Toyota Central R&D Labs., Inc., Japan

D12.3 **Optimization of Medium Frequency Transformers with Practical Considerations**
Kristen Booth, Harish Subramanyan, Xinyu Liang, Jun Liu, Srdjan Srdic, Srdjan Lukic
North Carolina State University, United States

D12.4 **An Efficient Analytical Inductor Core Loss Calculation Method for Two-Level and Three-Level PWM Converters Based on a User-Friendly Loss Map**
Jun Wang, Kfir J. Dagan, Xibo Yuan
University of Bristol, United Kingdom

D12.5 **Evaluation of an Automated Modeling Tool Applied to New 600 V, 2 a Vertical GaN Transistors**
Grace Watt[3], Alan Courtay[2], Amy Romero[3], Rolando Burgos[3], Rongming Chu[1], Dushan Boroyevich[3]
[1]HRL Laboratories, LLC, United States; [2]Synopsys, Inc., United States; [3]Virginia Polytechnic Institute and State University, United States

D12.6 **Induced Chaos in Speed Controlled Switched Reluctance Motor Drive**
Sen Li, Babak Fahimi
University of Texas at Dallas, United States

D12.7 **High Accuracy Temperaure-Dependent SOC Estimation Based on Real-Time Parameter Identification for Rechargeable Li-Ion Battery Pack**
Jinhyeong Park[2], Hynsu Bae[4], Sungsoo Jang[3], Woonki Na[1], Jonghoon Kim[2]
[1]California State University, United States; [2]Chungnam National University, Korea; [3]Korea Aerospace Research Institute, Korea; [4]RIpower, Korea

11:15 a.m. – 1:45 p.m.

D13: Control

Control

CHAIRS:

Martin Ordonez, *The University of British Columbia*

Lucas Lu, *GaN Systems*

D13.1 **Adaptive Dead Time Synchronous Rectification Control for High Efficiency LLC Resonant Converter**
Sangcheol Moon, Chengsung Chen, Dongjin Park
ON Semiconductor, Korea; ON Semiconductor, Taiwan

D13.2 **An Evolutionary Method to Achieve the Maximum Efficiency Tracking with Multi-Objective Optimization Based on the Genetic Algorithm**
Qinsong Qian[1], Qi Liu[1], Shen Xu[1], Weifeng Sun[1], Haisong Li[2]
[1]Southeast University, China; [2]Wuxi Chipown Micro-electronics limited, China

D13.3 **Accelerated Low Gate Count Parameter Identification for Integrated Switched-Mode Power Supplies with Digital Control**
Samuel Quenzer-Hohmuth[2], Jonas Messner[2], Steffen Ritzmann[3], Thoralf Rosahl[3], Bernhard Wicht[1]
[1]Leibniz University Hannover, Germany; [2]Reutlingen University, Germany; [3]Robert Bosch GmbH, Germany

D13.4 **An Efficiency Optimization Method for a High Frequency Quasi-ZVS Controlled Resonant Flyback Converter**
Shen Xu[1], Weidong Shen[1], Qinsong Qian[1], Jing Zhu[1], Weifeng Sun[1], Haisong Li[2]
[1]Southeast University, China; [2]Wuxi Chipown Micro-electronics limited, China

D13.5 **Discrete Time Adaptive State Feedback Control of DC-DC Power Electronic Converters**
Anushka Dissanayake, Nishantha Ekneligoda
Oklahoma State University, United States

D13.6 **Discrete Iterative Model and Dynamical Analysis of Inductor Current Compensation on Valley V^2 Controlled Boost Converter**
Haoyang Gan, Shengzhong He, Minrui Leng, Fuban Qin
Southwest Jiaotong University, China

D13.7 **A Wide Input and Output Voltage Range Battery Charger Using Buck-Boost Power Factor Correction Converter**
Jaya Sai Praneeth A.V., Sheldon S Williamson
University of Ontario Institute of Technology, Canada

D13.8 **A High Frequency Power and Area Efficienct Charge-Pump-Constant-on-Time Controlled DC-DC Converter Based on Dynamic-Biased Comparator with 50mV Droop and 2us 1% Settling Time for 1.15A/1ns Load Step**
Shih-Chieh Hsu, Ching-Jan Chen, Chieh-Ju Tsai
National Taiwan University, Taiwan

D13.9 **Adaptive Passivity Based Control of DC-DC Power Electronic Converters**
Anushka Dissanayake, Nishantha Ekneligoda
Oklahoma State University, United States

D13.10 **Optimal-Frequency Critical Soft Switching Method of Synchronous DC/DC Converter Based on Model Predictive Control**
Liwei Zhou, Matthias Preindl
Columbia University, United States

D13.11 **Variable-Frequency Explicit Model Predictive Control of Wide Band Gap DC/DC Converter with Critical Soft Switching**
Liwei Zhou, Matthias Preindl
Columbia University, United States

D13.12 **Efficient Load Management in Electric Ships: a Model Predictive Control Approach**
Nasibeh Zohrabi[1], Hasan Zakeri[2], Sherif Abdelwahed[3]
[1]Mississippi State University, United States; [2]University of Notre Dame, United States; [3]Virginia Commonwealth University, United States

D13.13 **Detection of Series DC Arc on a Distribution Node Using Discrete-Time Parameter Identification Techniques**
Kaushik Gajula, Luis Herrera, Xiu Yao
University at Buffalo, United States

D13.14 **A Virtual Impedance Based Grid Emulator for the Performance Analysis of Distributed Generations**
Nakul Narayanan K, Umanand Loganathan
Indian Institute of Science, India

D13.15 **Power Factor Improvement of Flyback PFC Converter Operating at the Light Load**
Minsung Kim[1], Oscar Montes[2], Sungho Son[4], Yoon-Geol Choi[4], Minjae Kim[3]
[1]Dongguk University, Korea; [2]North Carolina State University, United States; [3]Pohang Accelerator Laboratory, Korea; [4]Pohang University of Science and Technology, Korea

D13.16 **Indirect Grid Current Control of LCL Filter Based Grid-Connected Converter**
Subhajyoti Mukherjee, Pourya Shamsi, Mehdi Ferdowsi, Jonathan Kimball
MST Rolla, United States

D13.17 **A Distributed Control Architecture for Cascaded H-Bridge Converter**
Bei Xu[1], Hao Tu[2], Yuhua Du[2], Hui Yu[2], Hui Liang[1], Srdjan Lukic[2]
[1]Beijing Jiaotong University, China; [2]North Carolina State University, United States

D13.18 **Speed Ripple Suppression of Reduced DC-Link Capacitance IPMSM Drives for Air-Conditioning Applications**
Yin Bai, Nannan Zhao, Gaolin Wang, Guoqiang Zhang, Dianguo Xu
Harbin Institute of Technology, China

D13.19 **A Study of Voltage Feedforward Under Weak Grid Conditions**
Jianjie Xiao, Hua Lin, Ting Hua
Huazhong University of Science and Technology, China

D13.20 **A Robust Design Strategy for Resonant Controllers Tuned Beyond the LCL Filter Resonance Frequency**
Xin Zhao[2], Zhen Kang[2], Xuanlyu Wu[2], Weilin Li[2], Xiaohua Wu[2], Chuan Xie[3], Josep M. Guerrero[1]
[1]Aalborg University, Denmark; [2]Northwestern Polytechnical University, China; [3]University of Electronic Science and Technology of China, China

D13.21 **Single-Submodule Open-Circuit Fault Diagnosis for a Modular Multi-Level Converter Using Artificial Intelligent-Based Techniques**
Ziwei Ke, Jianyu Pan, Risha Na, Karun Arjun Potty, Julia Zhang, Jin Wang, Longya Xu
Ohio State University, United States

D13.22 **Current Programmed Mode Control of Multi-Level Flying Capacitor Converter Near Zero-Ripple Current Region**
Liangji Lu[2], Aleksandar Prodić[2], Giacomo Calabrese[1], Giovanni Frattini[1], Maurizio Granato[1]
[1]Texas Instruments Inc., Germany; [1]Texas Instruments Inc., Italy; [2]University of Toronto, Canada

D13.23 **Enhanced Current Capability for Modular Multilevel Converters by a Combined Sorting Algorithm for Capacitor Voltages and Semiconductor Losses**
Frederik Hahn[2], Markus Andresen[2], Marco Liserre[1]
[1]Christian-Albrechts-Universität zu Kiel, Germany; [2] Kiel University, Germany

D13.24 **Switching Sequence Synthesis for Minimizing RMS Current in a Single-Inductor-Multi-Output Converter**
Sounak Maji, K Hariharan, Santanu Kapat
Indian Institute of Technology Kharagpur, India

11:15 a.m. – 1:45 p.m.

D14: Applications for Wireless Power Transfer

Wireless Power Transfer

CHAIRS:

Sheldon Williamson, *University of Ontario Institute of Technology*

Brian Zahnstecher, *Powerrox LLC*

D14.1 **Two/Three-Coil Hybrid Topology for WPT Systems Charging Electric Bicycles**
Yang Chen, Naijian Yang, Lizhou Liu, Ruimin Dai, Zhengyou He, Ruikun Mai
Southwest Jiaotong University, China

D14.2 **An LCL-N Compensated Strongly-Coupled Wireless Power Transfer System for High-Power Applications**
Yiming Zhang, Zhengchao Yan, Ziwei Liang, Siqi Li, Chris Mi
San Diego State University, United States

D14.3 **Regulated Power Transfer Using Self-Tuned Networks for Capacitive Wireless Systems**
Eli Abramov, Alexander Mindel, Mor Mordechai Peretz
Ben-Gurion University of the Negev, Israel

D14.4 **Wireless Power Transfer Coil Design for Transmitter and Receiver LCC Compensation Based on Time-Weighted Average Efficiency**
Amir Masoud Bozorgi, Mehdi Farasat
Louisiana State University, United States

D14.5 **Analysis and Design of Hybrid Inductive and Capacitive Wireless Power Transfer System**
Bo Luo, Tao Long, Limou Guo, Ruikun Mai, Zhengyou He
Southwest Jiaotong University, China

D14.6 **High-Efficiency Design and Close-Loop Power Distribution Control for Double-Frequency Double-Load Magnetically Coupled Resonant Wireless Power Transfer System**
Ze Ding[1], Fuxin Liu[1], Yong Yang[1], Xuling Chen[1], Ralph M. Kennel[2]
[1]Nanjing University of Aeronautics and Astronautics, China; [2]Technical University of Munich, Germany

D14.7 **Multi-Frequency Phase-Shifted Angle Control Strategy for a Two-Phase MCR WPT System with Multiple Loads to Achieve Targeted Power Distribution and Stable Transmission Power**
Tianming Mei[1], Xin Zhang[1], Fuxin Liu[1], Xuling Chen[1], Ralph M. Kennel[2]
[1]Nanjing University of Aeronautics and Astronautics, China; [2]Technical University of Munich, Germany

D14.8 **A Single-Stage Three-Level AC/DC Converter for Wireless Power Transfer**
Minji Kim, Takongmo Marius, Gangwoo Lee, Jaesung Oh, Kyungjong Yoo, Eunsoo Kim, Ingab Hwang
Jeonju University, Korea

D14.9 **Behavioral Modeling of Resonant Power Transfer Systems with Capacitive Coupling: Two-Port Network Approach**
Eli Abramov[1], Mor Mordechai Peretz[1], Ilya Zeltser[2]
[1]Ben-Gurion University of the Negev, Israel; [2]Rafael Advanced Defense Systems Ltd., Israel

D14.10 **Bidirectional Wireless Power Transfer System with Wireless Control for Electrical Vehicle**
Benoit Sarrazin, Alexis Derbey, Paul Albouy, Jean-Paul Ferrieux, Gérard Meunier, Jean-Luc Schanen
Université Grenoble Alpes, CNRS, Grenoble INP, France

D14.11 **Investigation and Design of Wireless Power Transfer System for Autonomous Underwater Vehicle**
Yi Dou, Dehua Zhao, Ziwei Ouyang, Michael A. E. Andersen
Technical University of Denmark, Denmark

11:15 a.m. – 1:45 p.m.

D15: Renewable Energy System

Renewable Energy Systems

CHAIRS:

Serkan Dusmez, *Texas Instruments*

Saad Pervaiz, *Texas Instruments*

D15.1 **Adaptive Impedance Compensation of Inverters for Stable Grid Integration Based on Online Resonance Detection**
Wenchao Cao[1], Yiwei Ma[2], Fred Wang[2]
[1]Danfoss Turbocor Compressors, Inc., United States; [2]University of Tennessee, United States

D15.2 **A Novel Power Router with General AC and DC Port**
Tao Zhang[1], Gang Yao[1], Lidan Zhou[1], Nan Jin[3], Junwei Cao[2], Junfeng Hu[2], Chuantong Hao[2]
[1]Shanghai Jiao Tong University, China; [2]Tsinghua University, China; [3]Zhengzhou University of Light Industry, China

D15.3 **Performance Benchmark of Bypassing Techniques for Photovoltaic Modules**
Kamran Ali Khan Niazi[1], Yongheng Yang[1], Hassan Abbas Khan[2], Dezso Sera[1]
[1]Aalborg University, Denmark; [2]Lahore University of Management Sciences, Pakistan

D15.4 **A Small Signal Model for Grid Synchronization of a Three Phase SiC-Based Filter-Less Grid-Connected PV Inverter**
Yanjun Shi, Lu Wang, Hui Li
Florida State University, United States

D15.5 **Instantaneous Reactive Power Reduction of Ripple-Free Resonant Buck Converter Using Bidirectional Switch**
Hwasoo Seok[4], Seo-Gwang Jeong[4], Kwang-Seop Kim[4], Adrià Junyent-Ferré[2], Honnyong Cha[3], Minsung Kim[1]
[1]Dongguk University, Korea; [2]Imperial College London, United Kingdom; [3]Kyungpook National University, Korea; [4]Pohang University of Science and Technology, Korea

D15.6 **Design of Zero-Current Parallel-Switched-Capacitor Voltage Equalizer for Battery Strings**
Lizhou Liu[2], Wenbing Sun[2], Peibang Han[2], Ruikun Mai[2], Zhengyou He[2], Weihua Li[1]
[1]Jinan University, China; [2]Southwest Jiaotong University, China

D15.7 **Parameters Design of Pre-Synchronization for Multiple Virtual Synchronous Generator Based Microgrid**
Jiaqi Wu[1], Fang Zhuo[1], Chengzhi Zhu[2], Zhenxiong Wang[1], Hao Yi[1], Tongjia Wei[1]
[1]Xi'an Jiaotong University, China; [2]Zhejiang Electric Power Corporation, China

D15.8 **High Efficient Single-Phase Transformerless PV Inverter Using GaN HEMTs and Si MOSFETs**
Zhan Wang, Feng Qi, Yifeng Wu
Transphorm Inc., United States

D15.9 **Large-Signal Black-Box Modelling of Bidirectional Battery Charger for Electric Vehicles**
Antreas Naziris, Galo Guarderas, Airán Francés, Rafael Asensi, Javier Uceda
Universidad Politécnica de Madrid, Spain

D15.10 **Active Voltage-Ripple Compensation in an Integrated Generator-Rectifier System**
Phuc Huynh, Arijit Banerjee
University of Illinois at Urbana-Champaign, United States

D15.11 **Fault-Ride-Through (FRT) Characteristics of a Power-Decoupling-Type Photoinverter System**
Taiki Onodera, Toshihisa Shimizu
Tokyo Metropolitan University, Japan

D15.12 **A Novel Leakage Current Reduction Method Combining a PWM Method and Bypass Path with a Damping Network for Transformerless 3-Level Photovoltaic Power Conditioning System**
Seongeun Han, Jongmin Jo, Hanju Cha
Chungnam National University, Korea

D15.13 **Energy Capturing Performance Comparison Between Duty-Cycle Control and Current Control for Photovoltaic System**
Jaehyun Lee, Jongmin Jo, Hanju Cha
Chungnam National University, Korea

D15.14 **Mitigating Distribution Power Losses of Standalone AC Microgrids Using Particle-Swarm-Optimization Control for Distributed Battery Systems**
Yajie Jiang, Yun Yang, Siew-Chong Tan, Ron Shu Yuen Hui
University of Hong Kong, Hong Kong

D15.15 **A Scalable Soft-Switching Photovoltaic Inverter with Cascaded H-Bridge Cells and Galvanic Isolation**
Morteza Moosavi, Hamid A. Toliyat
Texas A&M University, United States

D15.16 **Coordinated Frequency Control of a Doubly-Fed Induction Generator and Battery Using the Flexible Power Reference**
Hyewon Lee[1], Moses Kang[2], Jongbok Baek[2], Jonghoon Kim[1]
[1]Chungnam National University, Korea; [2]Korea Institute of Energy Research, Korea

D15.17 **A Daily Optimization Method for a PV-Battery Microgrid Considering the Battery Lifetime and Time-of-Use Pricing**
Shuang Zhao[2], Xingchen Zhao[2], Chris Farnell[2], H. Alan Mantooth[2], Janviere Umuhoza[2], Yuzhi Zhang[1]
[1]ABB Inc., United States; [2]University of Arkansas, United States

D15.18 **Two-Stage Dual-Buck Grid-Tied Inverters with Efficiency Enhancement**
Li Zhang, Tao Zhang, Yongqiang Hao, Ben Wang
Hohai University, China

D15.19 **A Two-Stage Four-Port Inverter for Hybrid Renewable Energy System Integration**
Dianzhi Yu[1], Jianwu Zeng[1], Junhui Zhao[2], Jiahong Ning[1]
[1]Minnesota State University, Mankato, United States; [2]University of New Haven, United States

D15.20 **A Novel High Gain Single-Phase Transformer-Less Multi-Level Micro-Inverter**
Eltaib Abdeen[1], Mahmoud Gaafar[1], Mohamed Orabi[1], Mohamed Youssef[2]
[1]Aswan University, Egypt; [2]University of Ontario Institute of Technology, Canada

D15.21 **A Control Method for Dg Based on Automatic Current Slope Gain**
Gustavo P. Pontes, Jessica P. M. Rocha, Isaac S. de Freitas, Fabiano Salvadori, Camila S. Gehrke
Federal University of Paraiba, Brazil

D15.22 **A Novel DC Link Energy Shaping Process for Minimizing the Transient Frequency Variations in Microgrids**
Salman Harasis[2], Yilmaz Sozer[2], Malik Elbuluk[2], Haitham Abu-Rub[1]
[1]Texas A & M University, Qatar; [2]University of Akron, United States

D15.23 **A Wide Gain Range LLC Resonant Converter Based on Reconfigurable Bridge and Asymmetric Resonant Tanks**
Cheng Li, Haoyu Wang
ShanghaiTech University, China

D15.24 **Speed Sensorless Control Based on Stator Currents for PMSG Wind Energy Conversion Systems**
Ngoc Dat Dao, Dong-Choon Lee
Yeungnam University, Korea

D15.25 **A Smooth Transfer Control Strategy for Distributed Generation Units Based on Generalized Droop Control**
Xin Meng, Jinjun Liu, Zeng Liu
Xi'an Jiaotong University, China

D15.26 **Transient Performance Comparison of Modified VSG Controlled Grid-Tied Converter**
Yawei Wang, Bangyin Liu, Shanxu Duan
Huazhong University of Science and Technology, China

11:15 a.m. – 1:45 p.m.

D16: Transportation Power Electronics

Transportation Power Electronics

CHAIRS:

John Vigars, *Allegro MicroSystems*

Hengzhao Yang, *California State University Long Beach*

D16.1 **A Novel Power Balancing Technique in Neutral Point Clamping Multilevel Inverters for the Electric Vehicle Industry Under Distributed Unbalance Battery Powering Scheme**
Ahmed Sheir, Mohamed Youssef
University of Ontario Institute of Technology, Canada

D16.2 **An Improved Flying Restart Method of Sensorless PMSM Drive Systems Fed by an ANPC Inverter Using Repetitive Zero Voltage Vectors**
Dong-Woo Seo, Yeongsu Bak, Sungjoon Cho, Kyuchul Bae, Kyo-Beum Lee
Ajou University, Korea

D16.3 **Integrated Battery Charging Circuit and Model Predictive Current Controller for Hybrid Electric Vehicles**
Ho-Sung Kang, Seok-Min Kim, Kyo-Beum Lee
Ajou University, Korea

D16.4 **A Smooth Mode-Switching Strategy for Bidirectional OBC Base on V2G Technology**
Bodong Li, Lei Jing, Xiaoqing Wang, Ning Chen, Bo Liu, Min Chen
Zhejiang University, China

D16.5 **An Improved Low-Voltage Charging Circuit for Single-Phase Onboard Battery Chargers**
Hoang Vu Nguyen, Dong-Choon Lee
Yeungnam University, Korea

D16.6 **Hybrid Modulated Reconfigurable Bidirectional CLLC Converter for V2G Enabled PEV Charging Applications**
Umar Khalid[2], Haoyu Wang[1]
[1]ShanghaiTech University, China; [2]ShanghaTech University, China

D16.7 **A Class of GaN-Based, Radiation-Hardened Power Electronics for Jovian Environments**
Ansel Barchowsky, Ahmadreza Amirahmadi, Christopher Stell, Elvis Merida, Gary Bolotin, Gregory Carr
NASA Jet Propulsion Laboratory, United States

D16.8 **Smart Resistor for Stability Improvement of the DC Link in Turbo-Electric Aircrafts**
Karun Arjun Potty, Eric Bauer, Christian Moya, Benedict Sim, Jin Wang
Ohio State University, United States

D16.9 **A SiC Bidirectional LLC on-Board Charger**
Haoran Li, Shengdong Wang, Zhiliang Zhang, Jia-Cheng Tang, Xiaoyong Ren, Qianhong Chen
Nanjing University of Aeronautics and Astronautics, China

11:15 a.m. – 1:45 p.m.

D17: Misc Application

Power Electronics Applications

CHAIRS:

Liang Jia, *Google Power Group*

Yichao Tang, *TI*

D17.1 **Adaptive and Fast State of Health Estimation Method for Lithium-Ion Batteries Using Online Complex Impedance and Artificial Neural Network**
Zhiyong Xia, Jaber Abu Qahouq
University of Alabama, United States

D17.2 **Test Circuit Analysis and Evaluation of 400 VDC Appliance Coupler**
Naoki Hanaoka, Hidekazu Hoshi, Takashi Takeda
NTT Facilities Inc., Japan

D17.3 **Hybrid Subsea Power Cable Emulator**
Francisco Jose Viglus[1], Marcelo Lobo Heldwein[2]
[1]Federal University of Santa Catarina, Brazil; [2]Power Electronics Institute, Brazil

D17.4 **A Comparative Study of Battery, Supercapacitor and Undersea Energy Storage Systems in Wave Energy Applications**
Juan Nunez Forestieri, Mehdi Farasat
Louisiana State University, United States

D17.5 **Power Curve-Fitting Control Method with Temperature Compensation for All-Metal Induction Heating Systems**
Sang Min Park, Eun Su Jang, Byoung Kuk Lee, Dong-Myoung Joo
Sungkyunkwan University, Korea

D17.6 **A Low Profile Gate Drive Power Supply**
Ripunjoy Phukan[2], Lixiang Wei[1], Jiangang Hu[1]
[1]Rockwell Automation Inc., United States; [2]Virginia Polytechnic Institute and State University, United States

D17.7 **Experimental Analysis and Calibration of Power Losses in High Efficiency SiC Converters**
Maziar Mobarrez, Arun K. Kadavelugu, Harish Suryanarayana, Sandeep Bala
ABB Inc., United States

D17.8 **Multi-Physic Analysis for GaN Transistor PCB Layout**
Bainan Sun, Kasper Lüthje Jørgensen, Zhe Zhang, Michael A. E. Andersen
Technical University of Denmark, Denmark

D17.9 **A Multiplexing Ripple Cancellation LED Driver with True Single-Stage Power Conversion and Flicker-Free Operation**
Peng Fang[2], Yan-Fei Liu[1], Paresh C Sen[1]
[1]Queen's University, Canada; [2]University of Minnesota Twin Cities, United States

D17.10 **Bond Wire Damage Detection and State of Health Estimation of a 1200V, 900A Dual Pack IGBT Power Module Using the RL-Equivalent Circuit**
Abu Hanif[2], Joshua Major[1], Douglas Devoto[1], Faisal Khan[2]
[1]National Renewable Energy Laboratory, United States; [2]University of Missouri-Kansas City, United States

D17.11 **Adaptation of Commercial Current-Controlled Inverters for Operation with Virtual Oscillator Control**
Minghui Lu[4], Gab-Su Seo[2], Mohit Sinha[3], Fernando Rodriguez[1], Sairaj Dhople[3], Brian Johnson[4]
[1]Enphase Energy, United States; [2]National Renewable Energy Laboratory, United States; [3]University of Minnesota Twin Cities, United States; [4]University of Washington, United States

D17.12 **Thermal Monitoring Technique for Limiting Energy Accumulation in Automotive Power Switches Within SOA**
Eung Jung Kim, Sualp Aras, Kyle Schulmeyer, Abidur Rahman
Texas Instruments Inc., United States

D17.13 **Adaptive Deadtime Compensation for Magnetic Resonance Imaging Driver**
Huan Hu[1], Juan A Sabate[1], Xiaohu Liu[2]
[1]GE Global Research, United States; [2]Infineon Technology, United States

D17.14 **Isolated DC-DC Converter for Thermoelectric Energy Harvesting Based on a Piezoelectric Transformer**
Carlos Correa-Betanzo[2], Carlos Lopez-Perez[2], Aurelio Rodriguez[2], Adolfo Lopez-Nuñez[1]
[1]Instituto Tecnológico Superior de Irapuato, Mexico; [2]INTEL Tecnología de México S.A. de C.V., Mexico

D17.15 **Sub-Modular Circuit Design for Self-Balancing Series-Connected IGBTs in a Modular Multilevel Converter**
Lu Yue, Xiu Yao
University at Buffalo, United States

D17.16 **A Novel Time Domain Analysis of the LLC-L Resonant Converter for the Use of the CLL and LLC Resonant Converter**
Amit Kumar, Abhishek Awasthi, Omid Salari, Snehal Bagawade, Praveen Jain
Queen's University, Canada

11:15 a.m. – 1:45 p.m.

D18: Grid Applications

Power Electronics Applications

CHAIRS:

Ko-Tae Lee, *IBM*

Lanhua Zhang, *TI*

D18.1 **Two-Level Algorithm for UPQC Considering Power Electronic Converters and Transformers**
Jian Ye, Hoay Beng Gooi, Xinan Zhang, Benfei Wang, Ujjal Manandhar
Nanyang Technological University, Singapore

D18.2 **Low Voltage Distribution Grid Used Fault Current Limiter Controlled by Inverse Voltage Source**
Chaoran Zhuo, Xiaotian Zhang, Xiong Zhang, Xu Yang
Xi'an Jiaotong University, China

D18.3 **Proposal of Autonomous Regenerative Snubber Circuit and Verification Effect to Indirect Matrix Converter**
Koji Higashiyama[2], Fumito Kusama[2], Makoto Ozone[2], Keiji Akamatsu[2], Masakazu Michihira[1]
[1]Kobe City College of Technology, Japan; [2]Panasonic Corporation, Japan

D18.4 **A Modified Y-Source Inverter**
Hongpeng Liu, Yuhao Li, Zichao Zhou, Hui Wu
Harbin Institute of Technology, China

D18.5 **Relationship of Steady-State Power Loss and Configurable Tripping Time in Z-Source Circuit Breakers**
Sagar Bhatta[2], Yucheng Zhang[2], Ruiyun Fu[1]
[1]Mercer University, United States; [2]Old Dominion University, United States

D18.6 **Mission Profile Based Reliability Analysis of a Three-Phase PV Inverter Considering the Influence of High dv=dt on Parasitic Filter Elements**
Anup Anurag, Sayan Acharya, Shruti Pal, Subhashish Bhattacharya
North Carolina State University, United States

D18.7 **Control Strategy for Core-Loss Reduction in High-Frequency Transformers**
Nomar González-Santini, Fang Zheng Peng
Michigan State University, United States

D18.8 **An Optimal Control Algorithm of Capacitor Voltage Balancing for Modular Multilevel Converter**
XuFeng Zhang[2], Na Wang[1], HongJian Lin[2], Tao Yin[2], Ziwei Zhang[2], Zeliang Shu[2]
[1]ChengDu Yunda Technology Co.,Ltd, China; [2]Southwest Jiaotong University, China

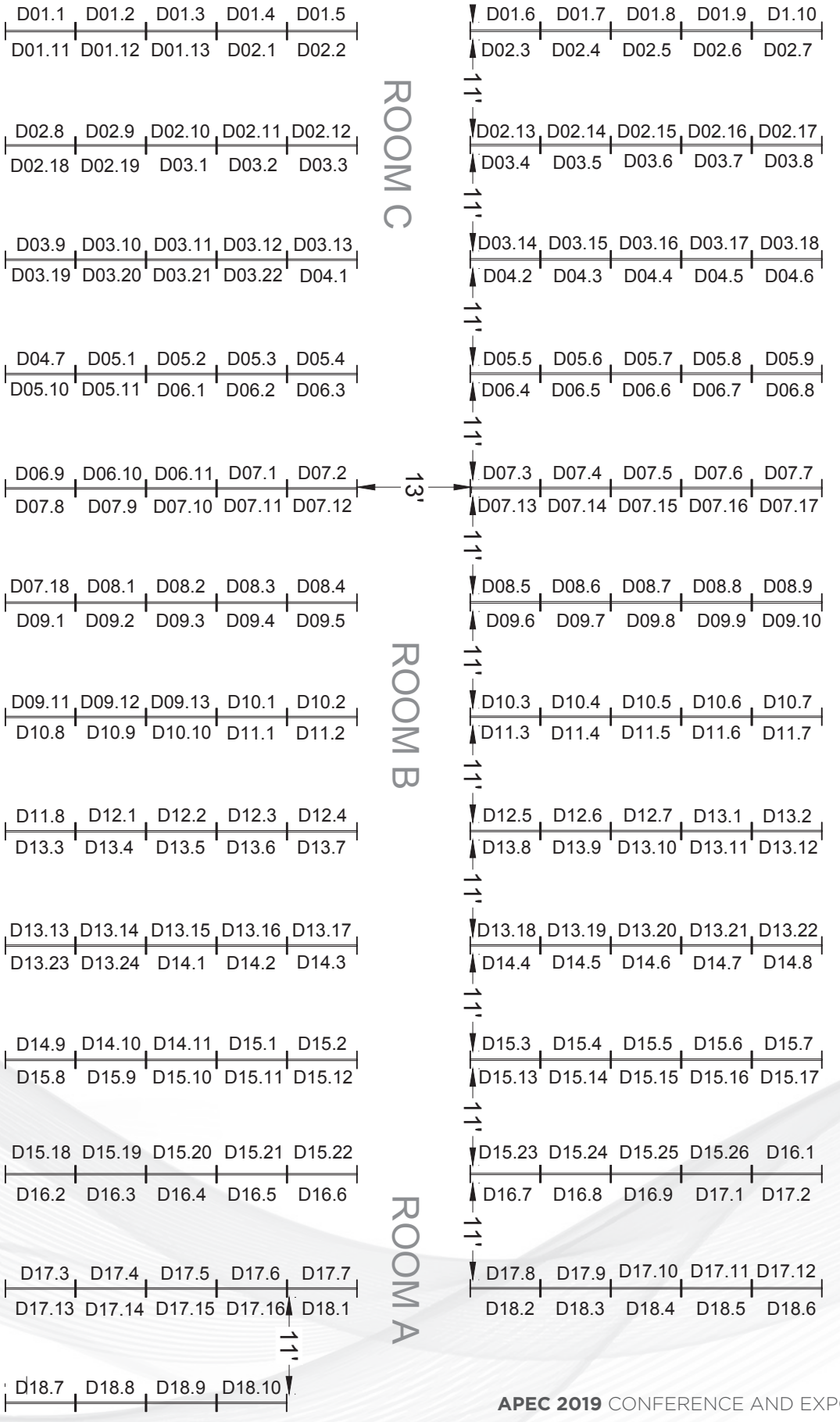
D18.9 **Stability Analysis of Multi-Paralleled VSCs with Mismatched Parameters**
Yangwen Wang, Donghua Pan, Xiongfei Wang, Hong Gong
Aalborg University, China

D18.10 **Highly Efficient Half Bridge with Press-Pack Diode for MMC Use**
Fabian Hohmann, Mark-Matthias Bakran
University of Bayreuth, Germany

NOTES

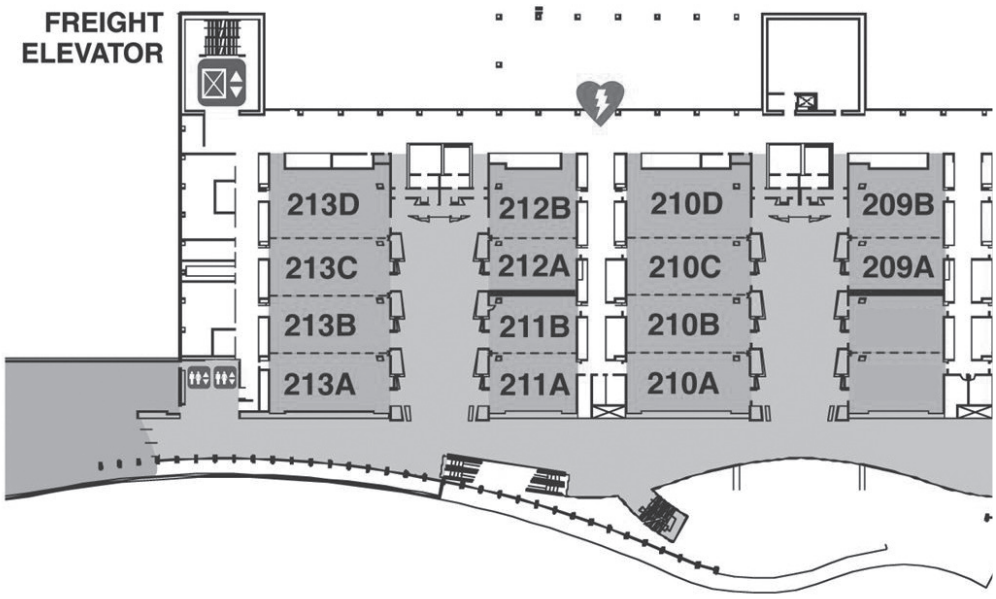
DIALOGUE SESSIONS FLOOR PLAN

124 DOUBLE SIDED POSTER BOARDS

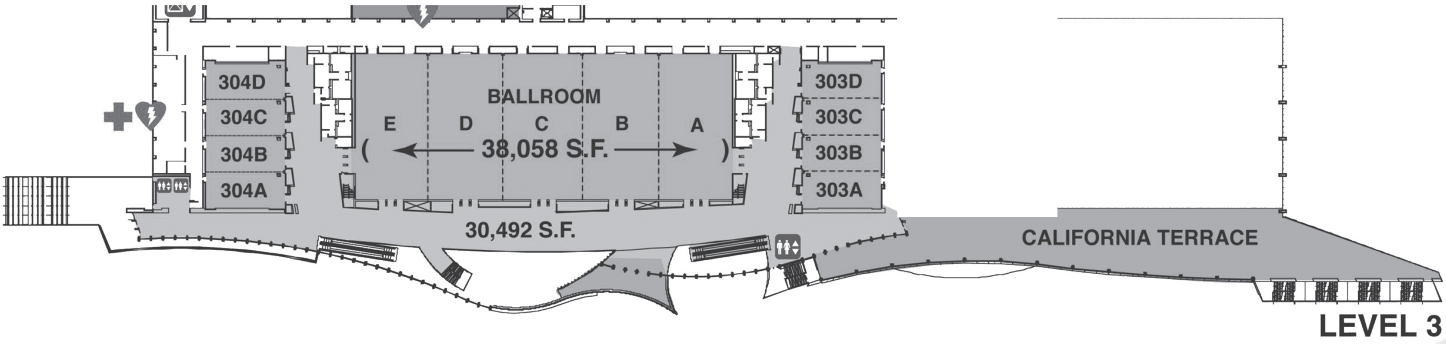


ANAHEIM CONVENTION CENTER FLOOR PLAN

LEVEL TWO



LEVEL THREE



LEGEND

- PRE-FUNCTION SPACE
- MEETING ROOM
- TERRACE
- FIRST AID STATION WITH DEFIBRILLATOR
- PASSENGER ELEVATOR
- FREIGHT ELEVATOR

EXPOSITION FLOOR PLAN

EXHIBITOR LISTING

EXHIBITOR	BOOTH #
5S Components	1120
AC POWER CORP. (Preen)	1141
ACME Electronics Corporation	1142
Acopian Power Supplies	846
Adaptive Power Systems	371
Advanced Technology (Bazhou) Co. Ltd.	675
AEM	1262
AgileSwitch, LLC	961
AIR-VAC Automation	1161
Aishi Capacitors	1238
All Flex Flexible Circuits and Heaters	972
Alpha & Omega Semiconductor	728
Altair	560
AMETEK Programmable Power	1265
AMETHERM, INC	456
AMOGREENTECH Co., Ltd.	1173
Amphenol Interconnect Products	1047
AMX Automatrix SRL	1162
Analog Devices	333
AnDAPT	342
Anhui Specialsun Electronic Technology Co., Ltd.	1370
Anpec Electronics	856
ANSYS, Inc.	339
APEC 2019 HUB	539
Apex Microtechnology	470
APM Technologies (Dongguan) Co. Ltd	365
ASC Capacitors-Shizuki Electric Company	1031
AVX	832
B&K Precision	1165
Baknor Thermal	1121
BH Electronics	1042
BMI	474
Boschman-Advanced Packaging Technology	1170
BOSE Research	241
Bourns, Inc.	774
Brownsburg Electronik	1267
CalRamic Technologies, LLC	1046
Celem Power Capacitors	565
Central Semiconductor Corp.	956
Centrotherm International AG	849

EXHIBITOR	BOOTH #
Chang Sung Corporation	567
Chroma Systems Solutions, Inc.	865
Classic Coil Company	575
Cleverscope	475
CogniPower	732
Coil Winding Specialist, Inc.	947
Coilcraft, Inc.	439
Coilmaster USA Inc	574
Cooliance, Inc.	965
Coowa, Inc.	1354
Cornell Dubilier Electronics	753
CPS Technologies	556
Cramer Magnetics	731
Cypress	1038
D6 Industries, Inc.	256
Danfoss Silicon Power GmbH	552
Datatronics	852
Dean Technology, Inc.	338
DEWESoft LLC	966
Dexter Magnetic Technologies	960
Digi-Key Electronics	1060
Dino-Lite Scopes	361
DMEGC Magnetics Co., LTD	847
Dongguan Mentech Optical & Magnetic Co., Ltd.	147
dSPACE Inc.	1242
Ducati Energia	234
EA Elektro-Automatik	433
Eaton	1061
EBG Resistors	340
ECI	629
EFC/Wesco	855
Efficient Power Conversion Corporation (EPC)	953
EGSTON Power Electronics	561
Electrocube, Inc.	542
Electronetics	363
Electronic Concepts, Inc.	321
Electronic Systems Packaging, LLC	926
Electronicon Kondensatoren GmbH	1174
Elna Magnetics	448
EMA Design Automation	1123

EXHIBITOR	BOOTH #
EMWORKS	1163
Epoxies, Etc.	1156
Fair-Rite Products	747
Ferrite International Co.	1133
Ferroxcube, Inc.	734
Focused Test, Inc.	231
Fuji Electric Corp. of America	827
Fujipoly America Corp	872
GAN Systems	553
GaNPower International Inc.	375
Gaotune Technologies Co., Ltd	1027
GE Global Research	1065
GeneSiC Semiconductor	1364
GES High Voltage, Inc	1252
GLOBALFOUNDRIES	440
Global Power Technologies Group	1224
GMW Associates	861
Goldenbamboo Electronics	970
Good-Ark Semiconductor	671
Gowanda Electronics	571
Group Intellect Power Technology	243
GW Instek	464
Haining Ferriwo Electronics Co., LTD.	864
Hangzhou Liansheng Insulation Co., LTD	1261
Hangzhou Silan Microelectronics Co., Ltd.	1132
Harwin Inc.	1257
HBM Test and Measurement	1270
Helix Semiconductors	472
Henkel Electronics LLC	446
Heraeus Electronics	564
Hesse Mechatronics	723
Hioki USA Corp.	247
Hitachi America, Ltd.	1254
Hitachi Metals	452
Hoi Luen Electrical Manufacturer Co., Ltd.	767
Holy Stone International	1040
Hubei Ruiyuan Electronic Co., Ltd	1035
HVM Technology	1175
HVR Advanced Power Components	838
IAS	539
ICE Components, Inc.	635
ICEL s.r.l.	1126
Ikonix USA	766
Illinois Capacitor	755
Indium Corporation	357
Infineon Technologies Americas Corp	711
Innoscience Technology Co., Ltd.	1273
Inter Outstanding Electronics Inc (IOE)	771
ITELCOND SRL	1360
ITG Electronics, Inc.	866
IWATSU ELECTRIC CO.,LTD.	943
JARO Thermal	1125
JFE Steel Corporation	1073
Jianghai America Inc	843
Johanson Dielectrics, Inc.	239
Jovil Universal LLC	1157
Kaschke Components GMBH	763
KDM Zhejiang NBTM Keda Magnetoelectricity Co. Ltd.	631
KEMET	653
Kendeil srl	227
KEPCO, Inc.	1124
Keysight Technologies	111
Kikusui America, Inc.	676
KITAGAWA INDUSTRIES America, Inc.	460
LEM USA, Inc.	1230
Li Tone Electronics Co, LTD	1166
Littelfuse, Inc.	253
Lodestone Pacific	749
LTEC Corporation	765
Mag. Layers USA	1233
MagnaChip Semiconductor	228
Magna-Power Electronics	824
Magnetic Metals Corporation	670
Magnetics	946
Malico Inc.	1234
MaxLinear Corporation	320
Menlo Microsystems, Inc.	1138
Mersen	447
Methode Electronics	142
MH GoPower Company Limited	1362

EXHIBITOR LISTING

EXHIBITOR	BOOTH #
Microchip Technology, Inc.	211
Micrometals, Inc.	853
MicroMouse 2019	189
Mitsubishi Electric US, Inc.	139
Mitsubishi Materials Corporation	773
MK Magnetics Inc	443
Molex, LLC	157
Monolithic Power Systems, Inc.	327
MORNSUN AMERICA LLC	939
Mouser Electronics, Inc.	661
MPS Industries, Inc.	353
MTL Distribution	355
NAC Semi	764
Naina Semiconductor Ltd.	1263
NAMICS Technologies Inc.	1140
Nanjing New Conda Magnetic Industrial Co. LTD	1164
National Magnetics Group/Ceramic Magnetics, Inc.	540
Navitas	1241
New England Wire Technologies	453
Newtons4th Ltd.	1153
NexGen Power Systems	1160
NH Research, Inc.	341
NIC Components Corp.	373
Nichicon (America) Corporation	665
Noratel/Plitron	677
NORWE Inc.	761
Ohmite Ceramic Resistor Division	1057
Ohmite MFG	727
ON Semiconductor	611
OPAL-RT TECHNOLOGIES	938
Pacific Sowa Corporation; C/O Epson Atmix Corporat	461
Paktron Capacitors	633
Panasonic	913
Payton America Inc.	429
PCIM Europe	854
Pearson Electronics, Inc.	948
PELS	539
PEM Ltd	863
Pfarr Stanztechnik GmbH	974
PIN SHINE INDUSTRIAL CO., LTD	463

EXHIBITOR	BOOTH #
Plexim	839
PMBus	226
PMK Mess- und Kommunikationstechnik GmbH	942
Polytronics Technology Corp.	1033
Power Integrations	1011
PowerAmerica	466
PowerELab Ltd.	831
Powersim, Inc.	324
Premier Magnetics	1366
pSemi, A Murata Company	1247
PSMA	539
Pulse Electronics	1147
PulserR, LLC	1264
Quik-Pak	1253
RECTRON SEMICONDUCTOR	1063
REMTEC, Inc.	235
Renco Electronics, Inc.	739
Renesas Electronics	347
Richardson RFPD	660
Ridley Engineering, Inc.	621
Rogers Corporation	820
Rohde & Schwarz USA, Inc.	230
ROHM Semiconductor	521
Rubadue Wire Company, Inc.	833
Rubycon	1064
Samwha USA Inc.	1039
SanRex Corporation	828
SBE, Inc.	930
Schunk Carbon Technology GmbH	871
Scientific Test, Inc.	941
Semikron, Inc.	821
Shaanxi Shinhom Enterprise Co., Ltd.	1260
Shandong Dongtai Electronics and Science Co.	1025
ShengYe Electrical Co. Ltd	465
Shenzhen Cenker Enterprise LTD.	150
Shenzhen Codaca Electronic Co., Ltd.	673
Shenzhen Zeasset Electronic Technology Co., Ltd.	457
Shindengen	1272
Shin-Etsu Silicones of America	154
Siemens PLM	1053

EXHIBITOR	BOOTH #
Silanna Semiconductor	860
Silicon Labs	772
Simplis Technologies	632
Sino Nitride Semiconductor Co. Ltd.	874
Sirectifier Electronics Tech Corp. of Jiangsu	1131
Sonoscan, Inc	857
Speedgoat	1352
SST Vacuum Reflow Systems	563
Standex Electronics	952
STAr Technologies Inc	1130
Stellar Industries Corp.	770
STMicroelectronics	311
Storm Power Components	223
StratEdge Corporation	148
Sumida America Components Inc.	1021
Superworld Electronics (S) PTE LTD	962
Synopsys, Inc.	1135
Taiwan Chinsan Electronic Ind. Co., Ltd.	1067
Taiwan Semiconductor Inc.	562
Taiyo Kogyo Co., Ltd.	1171
Tamura Corp. of America, Tamura HQ, Tamura China	664
TDG Holding Co., LTD	1155
TDK Corporation	811
Tektronix Inc.	471
Teledyne LeCroy	220
Texas Instruments	511
Thermik Corporation.	442
Tongfeng Capacitors	1071
Torotel Products, Inc.	1152
TowerJazz.	328
Toyochem Co., Ltd.	1139
Transim, EEtimes, EDN, Electronic Products,	528
Transphorm.	533

EXHIBITOR	BOOTH #
Tran-Tec	1172
Triad Magnetics	252
TT Electronics.	532
Typhoon HIL, Inc.	467
United Chemi-Con	420
United SiC	332
uPI Semiconductor/Sentec.	153
VAC Magnetics, LLC.	840
Ventec International Group	438
Verivolt	1266
Versatile Power	870
Viking Tech America Corporation.	224
Vincotech GmbH.	932
Vishay Intertechnology, Inc.	411
VisIC Technologies	775
Vitrek-High Voltage Test & Measurement	949
Voltage Multipliers, Inc.	1048
Wacker Chemical Corporation	964
Wakefield-Vette	760
Well Ascent Electronic (Ganzhou) Co., Ltd.	1255
WEMS ELECTRONICS	229
West Coast Magnetics	570
WIMA Capacitors GmbH & Co.KG.	928
Wolfspeed, A Cree Company	529
Wurth Electronics.	421
Xiamen Faratronic Co. Ltd.	1226
Yokogawa Corporation of America	538
Yole Developpement & System Plus Consulting	1240
Yuan Dean Scientific Co., LTD	572
ZES ZIMMER Inc.	225
Zhuhai Weihan Wire Co., Ltd.	672
Zurich Instruments, AG	1271

NOTES

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