



University of
Nottingham
UK | CHINA | MALAYSIA

The webinar is supported by the IEEE PELS TC11 - Aerospace Power, in cooperation with IES.

IEEE
**Industrial
Electronics**
Society



pels
IEEE POWER
ELECTRONICS SOCIETY
Powering a Sustainable Future

International Workshop on Electrical Technologies for Green Airports

Wednesday 28th April 2021 (Online) 14:00-17:40 Beijing Time

Schedule:

| | |
|--|-------------|
| Prof. Giampaolo Buticchi , UNNC (Introduction) | 14:00-14:20 |
| Prof. Jiawei Chen , Chongqing University | 14:20-15:00 |
| Prof. Zhixiang Zou , Southeast University | 15:00-15:40 |
| Prof. Xinbo Ruan , Nanjing University of Aeronautics and Astronautics | 15:40-16:20 |
| Prof. Jose I. Leon , Seville University | 16:20-17:00 |
| Prof. Marco Liserre , University of Kiel | 17:00-17:40 |

Organizers:

Prof. Giampaolo Buticchi, Prof. Pat Wheeler, Prof. Chris Gerada, Prof. He Zhang, Prof. Michael Galea, Prof. Serhiy Bozhko

Power Electronics Machines and Control Group – The University of Nottingham

Registration:

Jiajun Yang, jiajun.yang@nottingham.edu.cn



University of
Nottingham

UK | CHINA | MALAYSIA

The webinar is supported by the IEEE PELS TC11 - Aerospace Power, in cooperation with IES.

IEEE
Industrial
Electronics
Society



pels
IEEE POWER
ELECTRONICS SOCIETY
Powering a Sustainable Future

International Workshop on Electrical Technologies for Green Airports

Wednesday 28th April 2021 (Online) 14:00-17:40 Beijing Time

Welcome speech

Prof. Giampaolo Buticchi PhD

Zhejiang Key Laboratory for the More Electric Aircraft Technologies

University of Nottingham Ningbo China



Power Electronics, Machines and Control Research Group - World Leading Research



The University of
Nottingham

UNITED KINGDOM · CHINA · MALAYSIA

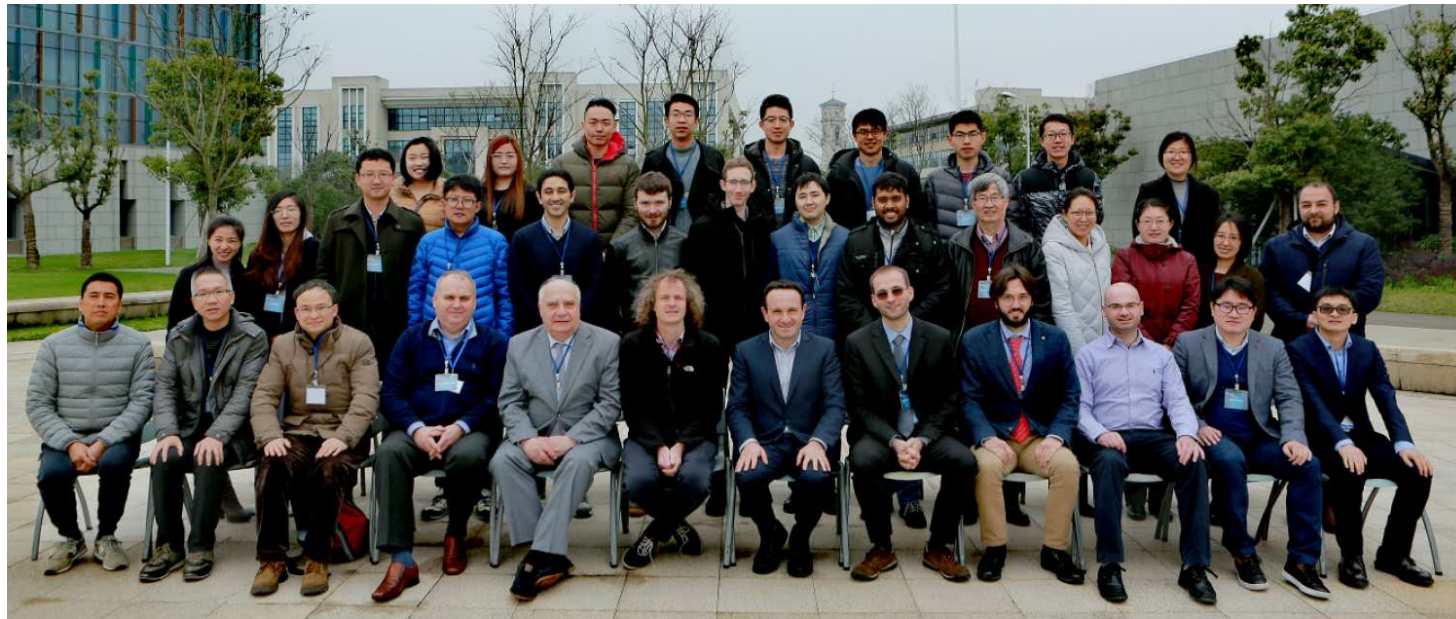
- Transport electrification and energy conversion
- Largest group world-wide with strong academic and industrial partnerships across the globe
- National leader – EPSRC centre for power electronics, APC electrical conversion spoke
- 60% of research income linked to industry





Power Electronics, Machines and Controls Group

- Over 30 team members in Ningbo China, and backed by PEMC group in UK
- Awarded with Municipal and Provincial-level awards, including the Zhejiang Key Laboratory on More Electric Aircraft Technologies
- Technical Areas: Electrical Machines, Power Electronics, Reliability, Thermal management
- Application Areas: Industrial, Automotive, Rail, Aerospace, Energy



PEMC International Workshop on Induction Machines - 2018

Nottingham (Yuyao) Electrification Research Institute was jointly established by University of Nottingham and Yuyao “Thousand Talent Plan” Industrial Park. NEC will be developed as a strategic platform with the major tasks of applied research, technology transfer and international business services in Yuyao.

The key focusing areas include the high performance industrial motor drive system, transportation electrification, high-speed drive system, electromechanical integration equipment.

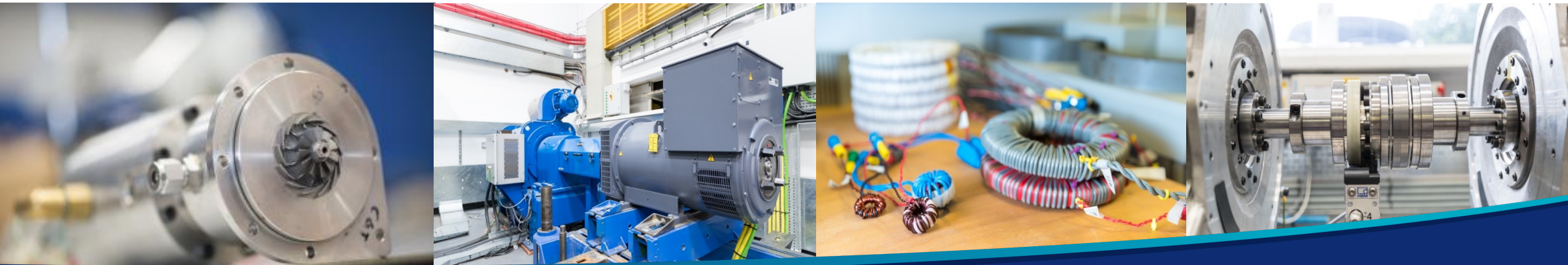


Overview

UNITED KINGDOM | CHINA



- High performance electrical machine - electromagnetic, mechanical & thermal design
- High performance drive - advanced control algorithms, hardware design of machine controller
- Power electronic converters - energy control and conversion



More electric transport

- Automotive
- Aerospace
- Marine logistics
- Railway transportation

Industrial drives-compressor

- Spindle
- Servo
- Compress
- Robotics
- Linear machine





**Electrical Technologies as Enabler for
Green Transportations and Greener
Airports**



New Air Travel Paradigm:

- Air travel is expected to keep increasing in the future.
- Worldwide, many countries have been drafting technological roadmaps for (e.g., Sustainable Aviation - UK Decarbonization Roadmap) for emission reduction in this scenario.
- The China Civil Aviation (CCA) 14th 5-year Plan envisages the strengthening of short-haul regional transport (with the creation of new airports) to promote economic growth and people mobility.
- The CCA 5-year plan is also focused on the creation of Type IV airports, with special focus on green technologies and electrification (中国民航四型机场建设行动纲要).

Future research possibilities (with focus on electrical technologies):

- Electric (regional) and Hybrid (medium haul) aircraft are being investigated to decrease emissions and travel cost.
- Integration of Renewable Energy sources.
- Airports need to take into account the new electric requirements.



- **Advanced Electrical Power Distribution System (on-board micro-grid)**
- **Storage**
- **Power Electronics**

High-power Electric machines



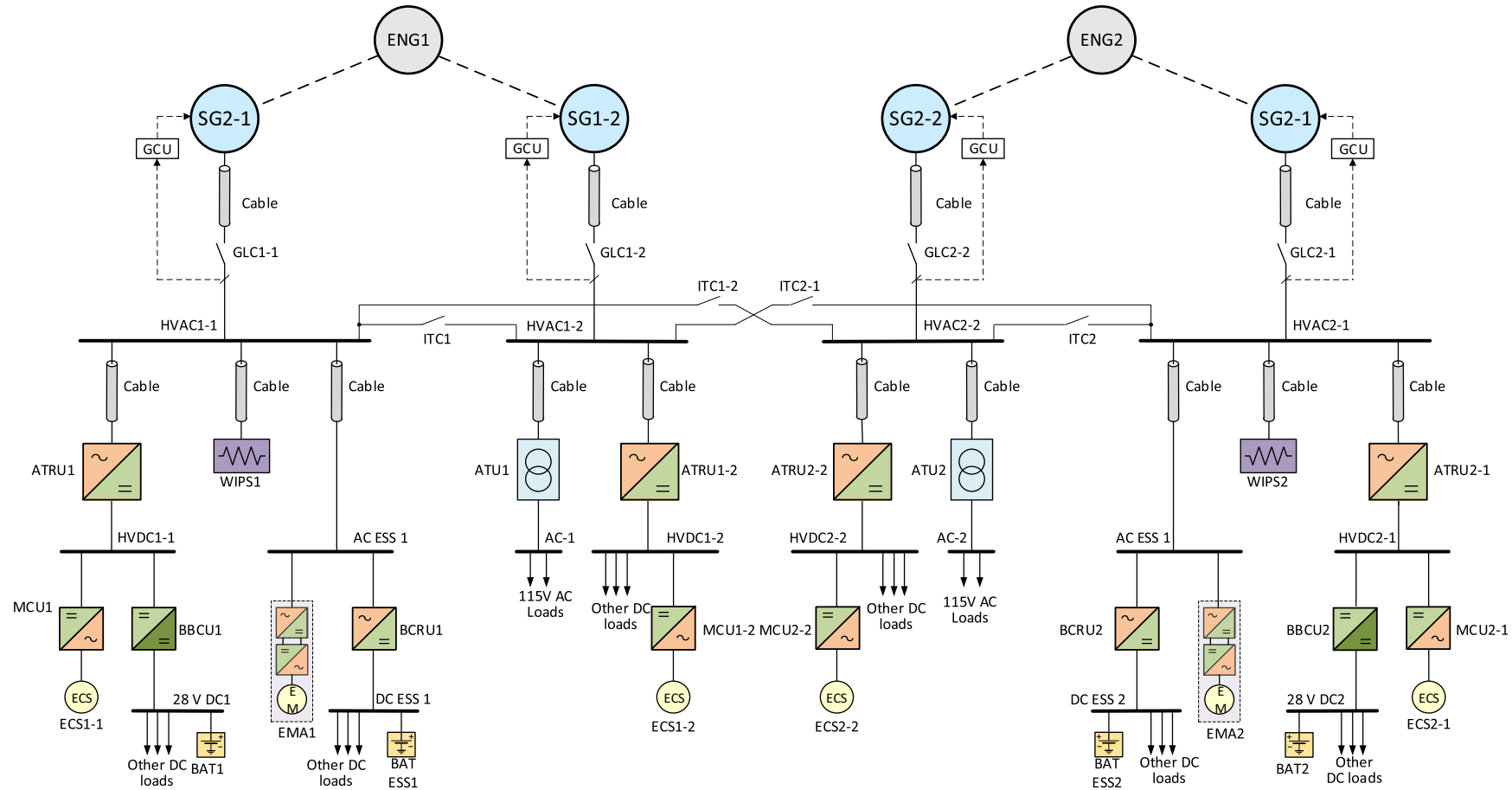
- **Connection to the national grid**
- **Renewable Energy Systems**
- **Electric Vehicles for airport logistics charging stations**
- **Hybrid/Electric Airplanes Charging**



Modular Multi-phase Architectures for the on-board Electrical Power Distribution System



MOET MEA EPS architecture



T. Wu, S. V. Bozhko, and G. M. Asher, "High speed modeling approach of aircraft electrical power systems under both normal and abnormal scenarios," in *2010 IEEE International Symposium on Industrial Electronics*, 2010, pp. 870–877



Challenges

- Increasing electrical power on-board
- Minimizing the redundancy while ensuring the fault tolerance
- Arbitrary power flow for operation optimization

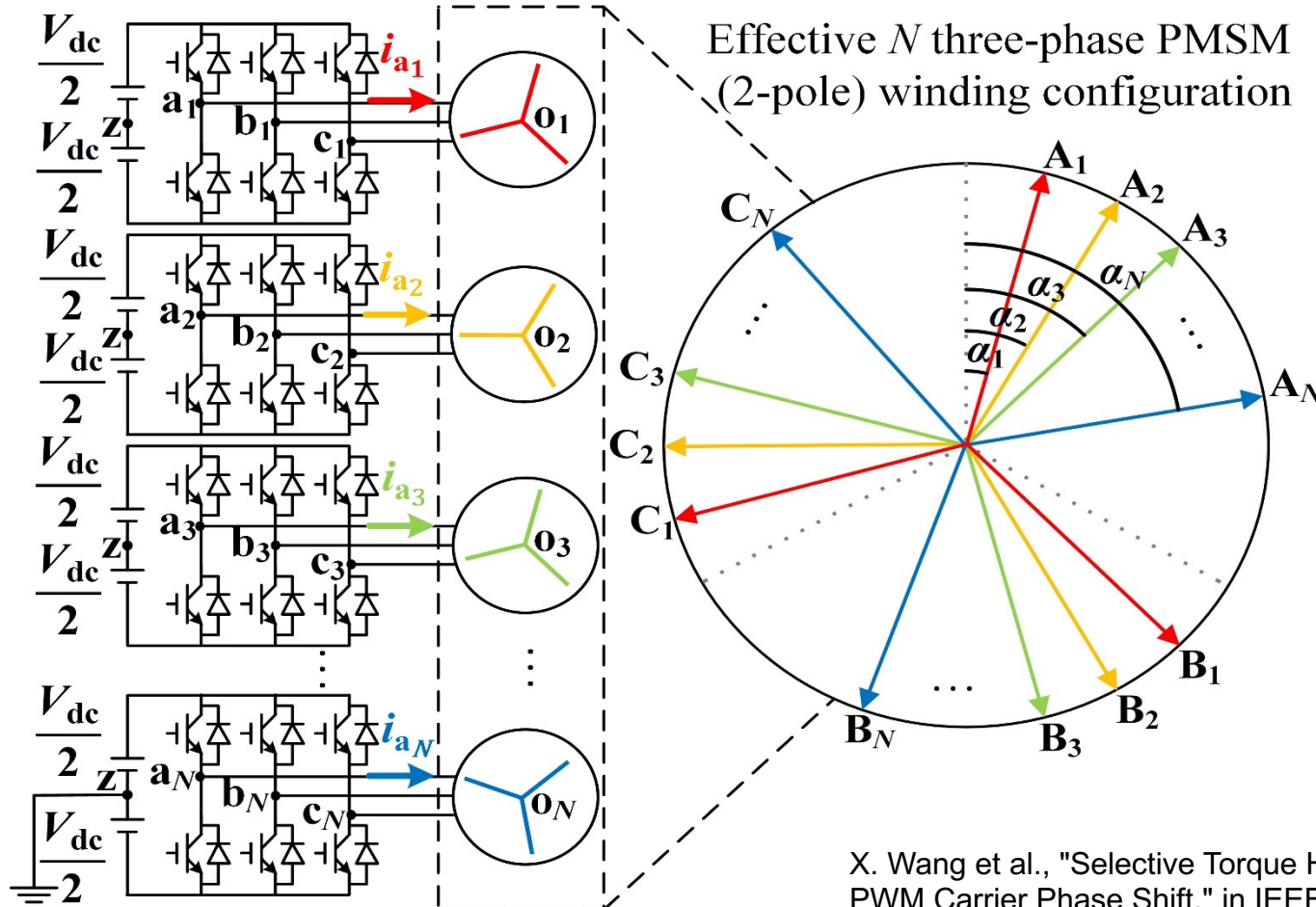
Hypothesis

- Multi-bus architectures
- Multi-port power electronics
- Multiphase electric machines
- Advanced controls

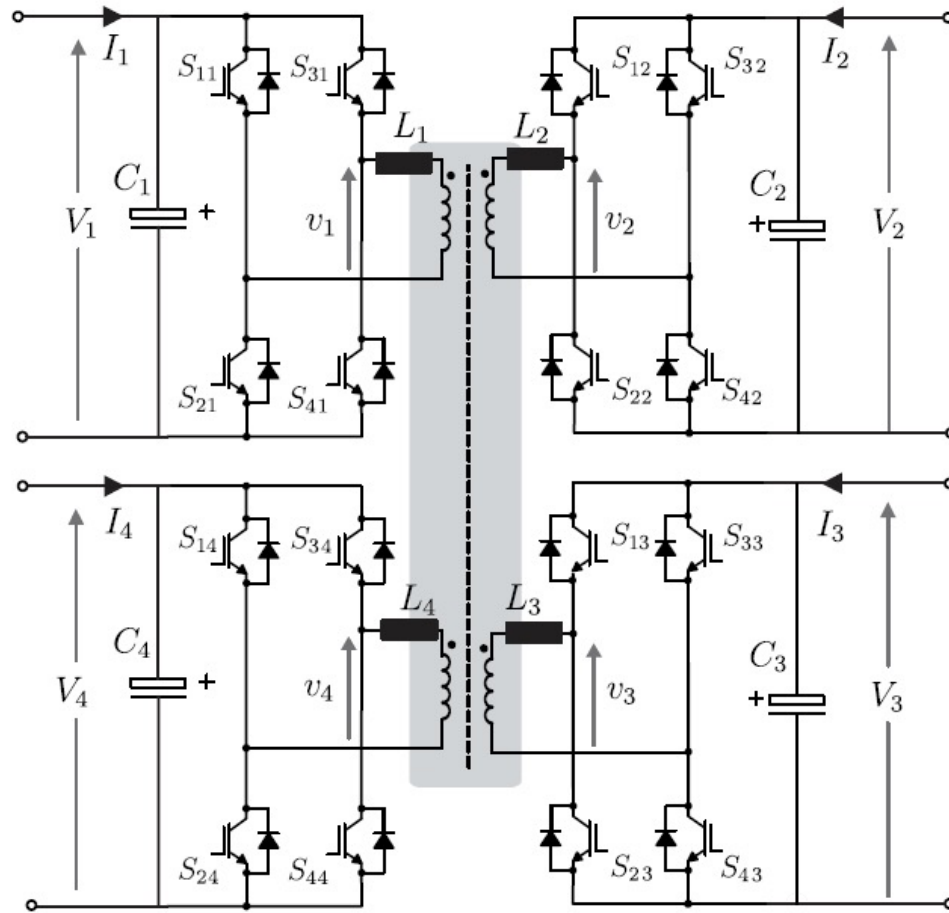


Modular three-phase electric drive

N modular converters N three-phase PMSM



- Intrinsic fault tolerance due to isolated three-phase systems.
- Advanced control capability thanks to the multiple degrees of freedom (torque ripple minimization)
- Potential for power density improvement.



Quadruple Active Bridge schematic.

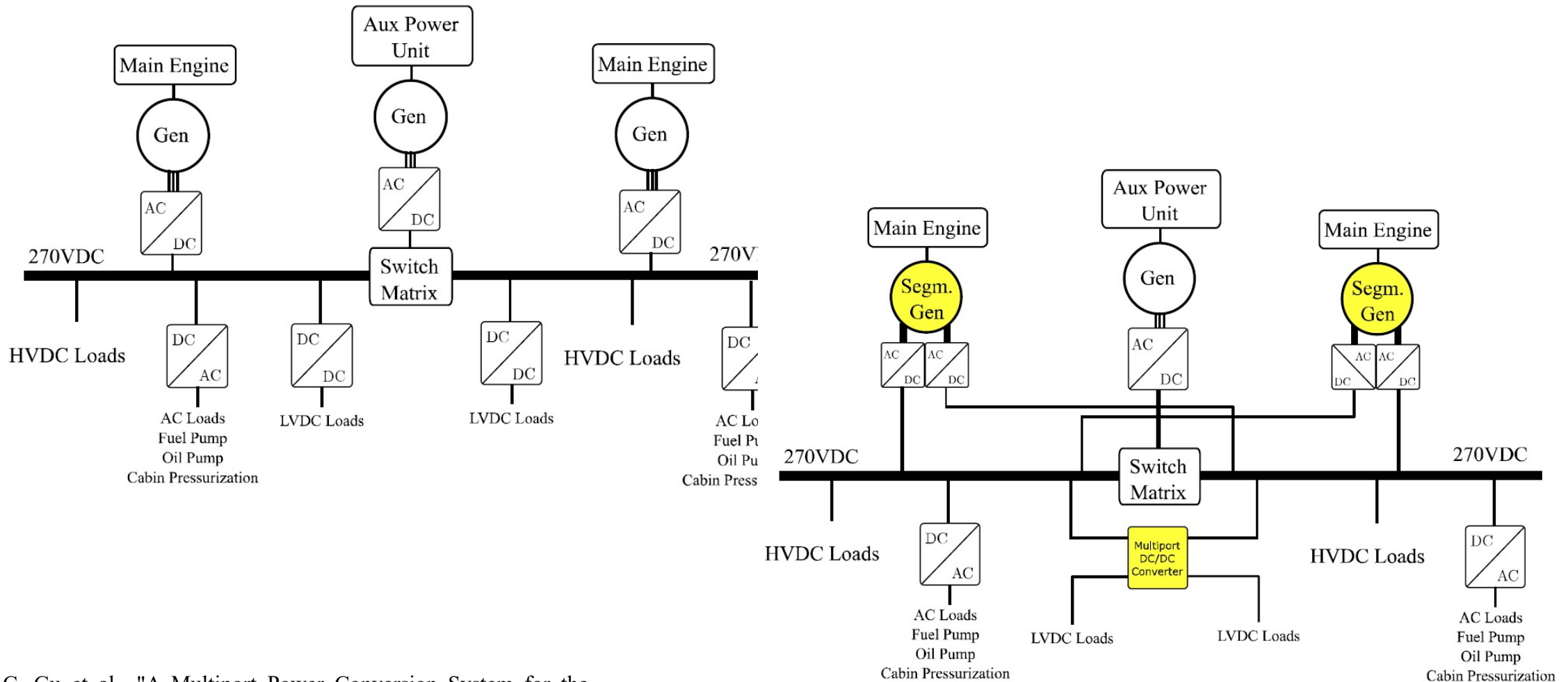
- Isolated voltage converter with soft-switching capabilities.
- Power density gain thanks to the multi-winding transformer shape optimization (30% compared to multi-converter system).
- Capability to handle arbitrary power flow for EPDS optimization.

G. Buticchi, L. F. Costa, D. Barater, M. Liserre and E. D. Amarillo, "A Quadruple Active Bridge Converter for the Storage Integration on the More Electric Aircraft," in *IEEE Transactions on Power Electronics*, vol. 33, no. 9, pp. 8174-8186, Sept. 2018.

T. Pereira, F. Hoffmann, R. G. Zhu and M. G. Liserre, "A Comprehensive Assessment of Multiwinding Transformer-Based DC-DC Converters," in *IEEE Transactions on Power Electronics*, 2021.



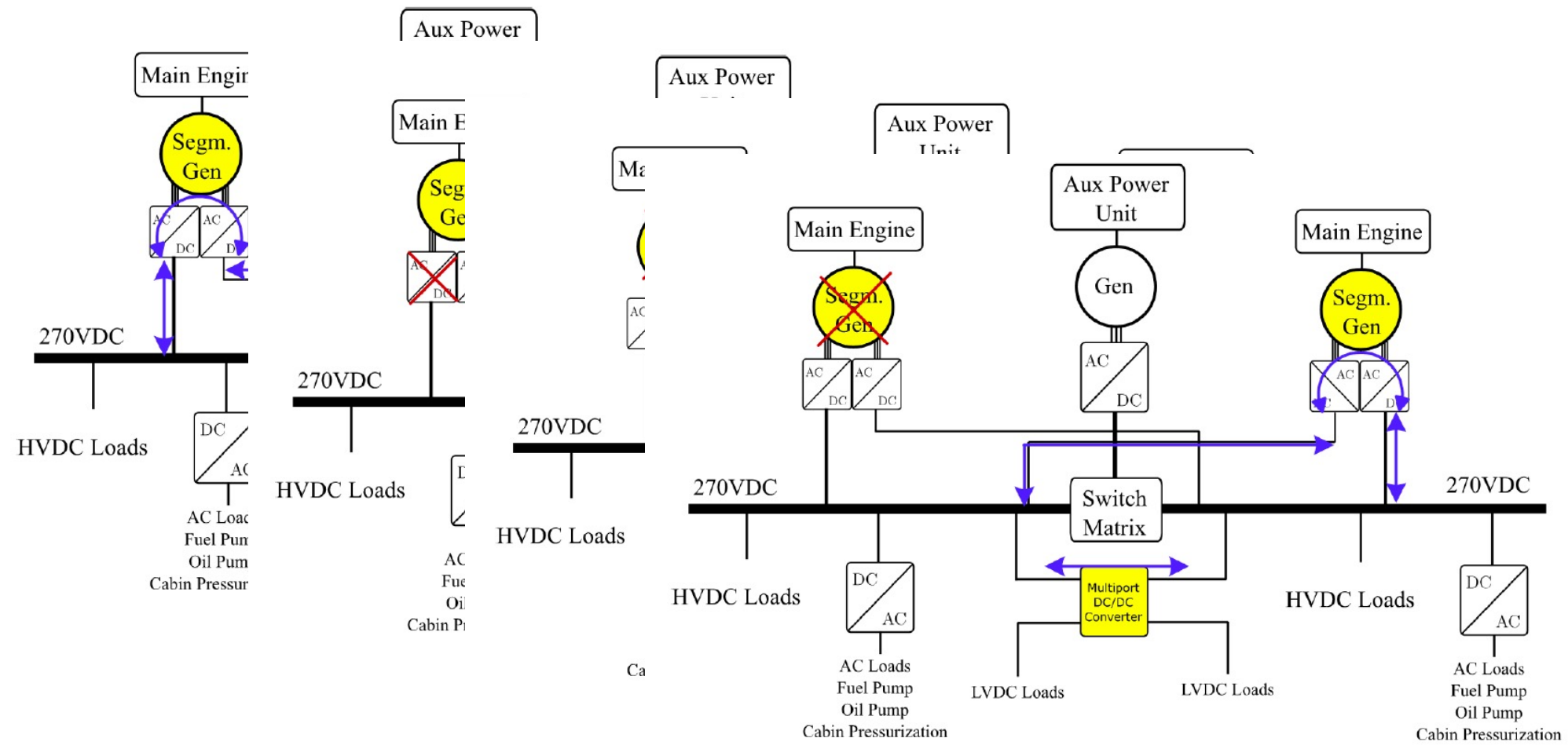
From single-input single-output to multi-port system



C. Gu et al., "A Multiport Power Conversion System for the More Electric Aircraft," in IEEE Transactions on Transportation Electrification, vol. 6, no. 4, pp. 1707-1720, Dec. 2020.



From single-input single-output to multi-port system



C. Gu et al., "A Multiport Power Conversion System for the More Electric Aircraft," in IEEE Transactions on Transportation Electrification, vol. 6, no. 4, pp. 1707-1720, Dec. 2020.



A multi-port EPDS can offer:

- Improved Power Electronics Power Density
- Improved Electrical Machine Power Density
- Improved power quality (torque ripple reduction, improved voltage control)
- Arbitrary Power Flow Capability
- Improved Fault tolerance

Future research areas:

- Energy management strategies at Aircraft Level
- Operation as grid-interactive microgrid when connected to the airport grid
- Contribution to Energy management within the Airport electrical grid



Thanks for the attention