Future Architecture of the Network
TE WHATUNGA HIKO

FAN2025

Future Architecture of the Network Conference Programme

Auckland NZ

4th and 5th February 2025

Welcome

Kia ora!

Electricity and electrification are seen as the significant enablers for decarbonisation of our nation. The Future Architecture of the Network (FAN) | Te Whatunga Hiko programme aspires to meet the challenges the electrical power system will face as we journey towards sustainable decarbonisation.

Our vision is to provide an infrastructure paradigm through a hybrid AC/DC transmission and distribution system that meets the needs of tomorrow's efficient, low-carbon, reliable and resilient electrical power system.

Funded as part of the New Zealand Government's Strategic Science Investment Fund (SSIF) on Advanced Energy Technology Platform (AETP), the research team is investigating what the future electrical power system might look like.

Join us to hear about the team's work now we are past the half-way point of this 7-year programme.

Attendance is in person at University of Auckland.

Ngā mihi nui,

Prof. Neville Watson,

Science Leader

For more information, please contact futurearchitecturenetwork@canterbury.ac.nz

To register, sign up here Future Architecture of the Network (FAN) Conference 2025

UC UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

UNIVERSITY OF AUCKLAND
Waipapa Taumata Rau
NEW ZEALAND

AUT

VICTORIA UNIVERSITY OF WELLINGTON
TE HERENGA WAKA

THE UNIVERSITY OF WAIKATO
Te Whare Wānanga o Waikato

Programme

Location: 405-470, Faculty of Engineering (entrance at 20 Symonds Street), University of Auckland

Day 0 - Monday 3rd February (networking)

Tea/Coffee available		
14:00 – 16:00	Setting up of FAN posters	Open session
16:00 – 17:45	Informal networking with FAN-invited international experts with light refreshments	Open session
18:30 – 21:00	Welcome dinner for FAN Leadership Team and Key Researchers with international experts	Closed

Day 1 - Tuesday 4th February

From 9:30	FAN Conference registration (tea/coffee)		
10:00 – 10:05	Tipene Merritt	Mihi Whakatau	Open session
10:05 – 10:15	Nirmal Nair	Health & Safety and Welcome	Open session
10:15 – 10:45	Neville Watson	Introduction to FAN and mid-term progress	Open session
10.45 – 11.45	Subhashish Bhattacharya	Keynote: Solid State Transformer journey – from concept to pilot demonstration in a decade, and Solid-State DC Transformers for DC Grids	Open session
11.45– 13:00	Lunch break and networking alongside poster boards		
13:00 – 14:00	Neville Watson	Workstream 1 Researchers Panel (50 minutes) + Q/A (10 minutes)	Open session
14:00 – 15:00	Nirmal Nair	Workstream 2 Researchers Panel (50 minutes) + Q/A (10 minutes)	Open session
15:00 – 16:00	Tek Lie	Workstream 3 Researchers Panel (50 minutes) + Q/A (10 minutes)	Open session
16:00 – 16:15	Afternoon tea		
16:15 – 17:15	Neville Watson	Workstream 4 Researchers Panel (50 minutes) + Q/A (10 minutes)	Open session
17:15 – 18:15	Tipene Merritt	Vision Mātauranga (VM) (50 minutes) + Q/A (10 minutes)	Open session
18:15 – 18:20	Nirmal Nair	Closing off Day-1 and Logistics for Day-2	Open session
19:30	Dinner Venue TBC		Registered attendees

Day 2 – Wednesday 5th February

Location(s):

UoA-City: 405-470, Faculty of Engineering

AUT: Engineering, Computer & Mathematical Sciences – Level 3, WZ building *

UoA-Newmarket: 314-390 Khyber Pass Road, Newmarket, Auckland 1023 *

9.00 – 10.00	405-621 Room	Science Advisory Group meeting	Closed
9:00 – 9:45	Yuan Liu and Saad Khan	Lab tour- WS2 facilities (UoA-Newmarket)*	Open session
	Tek Tjing Lie	Lab tour- WS3 facilities (AUT) *	
10:00 – 10:30	Leyla Zafari and Yuan Liu	Lab tour- WS1, WS2, and WS3 facilities (UoA-City 405-628 Power system lab)	Open session
9:00 – 10:30	Felipe Arrano-Vargas	Tutorial: Hardware-in-Loop for Grid Interconnection (405-470)	Open session
10:30 – 10:45	Refreshments		
10:45– 12:00	Facilitated by Hamish Avery and Nirmal Nair	Industry talks - Kuntal Satpathi and Tarek Lamara	Open session
12.00 – 13.00	Lunch break and networking alongside poster boards		

***Those attendees, who do not opt for the tutorial will have option to go in the morning to either AUT, UoA-Newmarket visit (transport will be arranged) and then visit UoA City campus FAN facilities.**

Split into separate Management and Research Student sessions:

Management session

13.00 – 13.45	405-621	RLT meeting and KPI review	RLT members
14:00 – 15:00	405-621	Advisory Board meeting	Closed

Research Student session:

13.00 – 15:00	Co-Chairs: Josh Schipper (UC), Veerabrahmam Bathini (UC) and Yuan Liu (UoA)	~ 6 min presentations of work (completed or planned), including personal introduction to the group.	Students and research staff

15.00 – 15.30	Neville Watson	Conference close	Open session

Keynote presentation: Solid State Transformer journey – from concept to pilot demonstration in a decade, and Solid-State DC Transformers for DC Grids

Prof. Subhashish Bhattacharya

The Solid-State Transformer [SST] journey from concept to pilot demonstration in a decade will be presented. The SST is shown to be an enabler for DC distribution grids at any node of the AC distribution system. The DC Grid provides an efficient, and economic solution for Data Centre power supplies, EV charging infrastructure, DC Microgrids, Electrolysers, and several other applications. The SST for grid interconnection at MV are enabled by the advances in HV SiC power devices at 10-15kV blocking voltages. The design, control, development, and testing of SST with HV SiC 10kV MOSFETs and 15kV SiC IGBTs will be presented. A pilot demonstration of an MV 4160V, 100kVA SST with SiC 10kV MOSFETs will be discussed. Solid State DC Transformers for DC Grids at both MV DC and LV DC enabled with HV SiC power devices integration of distributed and renewable energy will be enumerated.

Professor Subhashish Bhattacharya
Duke Energy Distinguished Professor,
Electrical and Computer Engineering,
North Carolina State University

Subhashish Bhattacharya is currently Duke Energy Distinguished Professor in the Department of ECE at NC State University. He received B.E. from University of Roorkee [IIT-Roorkee], India in 1986, M.E. from IISc in 1988, India, and Ph.D. from University of Wisconsin-Madison in 2003, all in electrical engineering. He was with FACTS and Power Quality Division at Westinghouse R&D and Siemens Power Transmission & Distribution, from 1998 to 2005. He joined NCSU in August 2005, where he is a founding faculty member of NSF FREEDM Center, ATEC, and DoE PowerAmerica Institute. A part of his PhD research on active power filters was commercialized by York Corporation [now Johnson Controls]. His research interests are Solid-State Transformers with HV SiC devices, Integration of renewable energy resources, Microgrids, high-frequency magnetics, active filters, and the application of new power semiconductor devices such as SiC and GaN for power converters. His research is funded by several industries, NSF, DoE/ARPA-E, Navy, NASA, and others. He has over 800 publications, 12 patents, H-index of 78, and 25,200+ citations.

https://research.ece.ncsu.edu/bhattacharya/

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Google Scholar: https://scholar.google.com/citations?hl=en&view_op=list_works&gmla=AJsN-F5_XrBXIgwQDCWZQhUeDP8QseiqWCjMOptmOOAO1blLgCht6PfK_Rp0AXezxBMQfDnUBM8DVhgxPcJNqdsLL9Xt1kNzv66yp6XRRvJTH3hApxHw01A&user=wNWF8-AAAAAJ

Workstream 1 update – Software Tools for the Architecture of the Hybrid AC-DC Grid

Tuesday 4th February 13.00 – 14.00

Presented by Prof. Neville Watson

Planning AC-DC grids requires power system tools for building its architectural design. Workstream 1 is developing the tool capabilities of the FAN project for the benefit of all New Zealanders and those abroad. These tools include steady-state analysis tools to assess current and power flows, such as on a potential New Zealand HVDC grid to optimise renewable energy resources along the length of the country. Also included is a dynamic analysis tool to verify the stability of DC grids for the expansion of DC homes, electric vehicle charging infrastructure, distributed and renewable generation and the decarbonisation of many industries and businesses.

This update will present the progress towards the long-term goals of developing power-flow, short-circuit analysis and dynamic analysis tools, the potential architectural design of the hybrid AC-DC system, as well as the on-going goal of increasing the knowledge and capabilities of New Zealand engineers. We have engaged four Summer Students since our last update. Furthermore, our three PhD students have settled into their projects. The first PhD student, Choidorj Adiyabazar, is developing a physical prototype DC-DC converter to verify theoretical stability results. The second PhD student, Christian Yap, is developing ideas for a steady-state fault analysis tool. The third PhD student, Dilshani Maheepala, has joined this year to extend our capabilities in the dynamic analysis tool. Workstream 1 is lead and supported by the expertise of the principal investigators Dr Radnya Mukhedkar, Prof. Neville Watson, Assoc. Prof. Nirmal Nair, the supervision of Assoc. Prof. Alan Wood and Dr Jeremy Watson, and the research of Dr Veerabrahmam Bathini and Dr Josh Schipper.

Workstream 2 update – Objective of FAN WS2 Workstream

Tuesday 4th February 14.00 – 15.00

Presented by Prof. Nirmal Nair

The current AC circuit topologies (the way things are connected to form functional circuits), have been developed and refined over many years.

In WS2 we will determine new DC and AC/DC circuit topologies.

We need to consider

1. new ways of fault detection, location and isolation, ensuring safety and minimising outage
2. curtailing DC egress into AC networks and,
3. ways to ensure continued stable operation after fault isolation.

Our target to date: *We have investigated dedicated DC bus architecture within MV and LV networks; disparate AC/DC converter topologies within DC network; and comprehensively investigated all the necessary control, protection and isolation methods for operating combinations of HV/MV/LV networks within a hybrid AC/DC network. We will work with Transpower, EDBs and local and international manufacturers as may be applicable*.

This presentation will cover through how our activities have been progressing through 2 completed Masters; several short-term summer, Taught Masters research and BE final year projects and 3 ongoing PhDs and Research Fellow investigations. It will also highlight the national engagement undertaken through the EEA, CIGRE NZ workshops, and with NZ based electricity stakeholders (details of which will be shared during the poster session). The international engagements through 3 major IEEE conferences IEEE TENCON 2021, EGRID 2022 and ISGT-ASIA 2023 which includes dedicated panel sessions, paper presentations and chairing of sessions both across the FAN program and specifically to WS2 will also be quickly reviewed. Our commissioned experimental facilities for building integrated ELV, LV Microgrid and MTDC emulation across two campus (City & Newmarket) of University of Auckland Power system research facilities is scheduled as part of Lab-tour on day 2 of this hui/workshop.

This update will end with sharing of ongoing plans of research and development activities and researcher exchange planned in the coming two years with North Carolina State University-USA, University of New South Wales- Australia, TU Eindhoven- Netherlands and KU Leuven, Belgium.

Workstream 3 update

Tuesday 4th February 15.00 – 16.00

Presented by Prof. Tek Lie

One of the key challenges facing the future of DC and hybrid AC/DC grids lies in the technological development and precise control of power electronic converters. These components are vital for ensuring stability and efficiency within modern and future power systems. Real-world instabilities in hybrid AC/DC systems, such as those observed in wind farms, underscore the critical need for advanced solutions. Among the essential components for future DC grids are DC breakers, which remain a significant technical hurdle. The absence of a natural zero crossing in DC systems complicates the task of breaking arcs, making the development of DC breakers both technologically challenging and crucial for the widespread adoption of DC grids.

Despite these challenges, exciting opportunities arise from leveraging recent advancements in technology, including artificial intelligence, advanced communication systems, cutting-edge control and optimization theories, and the dramatic improvement in processing power. These innovations hold immense potential to enable the design of robust, efficient, and intelligent grids that can seamlessly integrate DC and AC systems while meeting the growing demands of the energy landscape.

This workstream focuses on addressing these critical technological challenges and advancements, which are pivotal to unlocking the full potential of DC grids. The overarching objective is to facilitate the integration and proliferation of DC grids within the existing AC infrastructure by advancing the technologies and control mechanisms for various types of power electronic converters. These include:

1. DC Networks Connected to AC Grids: These involve converter terminals that convert AC power into DC power and vice versa, enabling smooth interaction between AC and DC systems.
2. DC-DC Converters: These are essential for changing DC voltage levels, enabling greater flexibility and efficiency in DC grids.
3. DC Breakers: These components rely on enabling technologies to provide fault protection in DC grids, a challenging area due to the lack of zero crossing for arc interruption.

This workstream encompasses a range of projects that explore these technologies. For example, we are engaged in national and international collaborations on the development of various forms of DC/DC converters, advanced control mechanisms for AC/DC converters, and innovative solutions for DC breakers. Our research on converter control broadly investigates the application of transformative techniques from control theory, machine learning, and related fields to enhance system performance and stability. In parallel, our work on DC breakers explores the promising role of superconductors, which could revolutionize fault interruption in DC systems.

This presentation will provide an overview of the progress achieved so far in these areas, outline a detailed roadmap for future research within the workstream, and discuss how the advancements we are pursuing can enable the full potential of DC grids. By addressing these challenges, this workstream aims to contribute significantly to the development of the next-generation power systems that are smarter, more reliable, and capable of meeting the energy demands of the future.

Workstream 4 update

Tuesday 4th February 16.15 – 17.15

Presented by Prof. Neville Watson (for Dr. Andrew Lapthorn)

There has been a massive investment globally in building and maintaining our electric power system, and this legacy equipment can act as a barrier to the transition to a DC-based grid. Workstream 4 is concerned about how the transition from AC to DC can be achieved and what parts of our current network are compatible with DC.

Our work has focused on the modelling and testing of components and accessory compatibility for use in a DC system, including insulators, cables, and switching devices.

Our research focus includes the following areas:

- The use of medium-voltage AC cables in DC systems.
- Assessing power transformer's susceptibility to DC egress through testing in our high-voltage laboratory and through on-site experiments at the Haywards substation using the HVDC link.
- Designing and modelling medium-voltage, medium-frequency transformers for use in new DC-DC converters.
- Developing a DC Home demonstrator.

This presentation will go through the work to date, outline plans for the remainder of the research, and seek feedback from the audience.

Workstream 5 update

Tuesday 4th February 17.15 – 18.15

Presented by Tipene Merrett and Assoc. Prof. Ramesh Rayudu

Vision Mātauranga policy relates to unlocking science and innovation potential of Maori knowledge, people and resources leading to the greater benefit of New Zealand. It is categorised into 4 themes: Indigenous Innovation; Mātauranga; Hauora/Health; and Taiao/Environment

All 4 themes are relevant to FAN, but as part of the project (Workstream 5) we have focussed on:

- Indigenous innovation: Contributing to economic growth through distinctive research and development
- Taiao/Environment: Achieving environmental sustainability

Further to this, Workstream 5 is premised on: Build capacity into the Research team; Co-development of projects; Build the capability of Māori individuals or groups; and Dissemination and outreach.

As the FAN project nears the final 2 years of its 7-year life cycle, this presentation will discuss past achievements, their impact on the community so far, and will also layout the work that lies ahead.

Lab tours

Wednesday 5th February

WS2 facilities - UoA-Newmarket: 314-390 Khyber Pass Road, Newmarket, Auckland 1023

9.00 – 9.45

Join Leyla and Saad for a tour of the University of Auckland Electrical, Computer, and Software Engineering (ECSE) department's Power Systems laboratory facilities at the Main and the Newmarket campuses.

Newmarket Laboratory

WS3 facilities - AUT Power Systems Research Laboratory

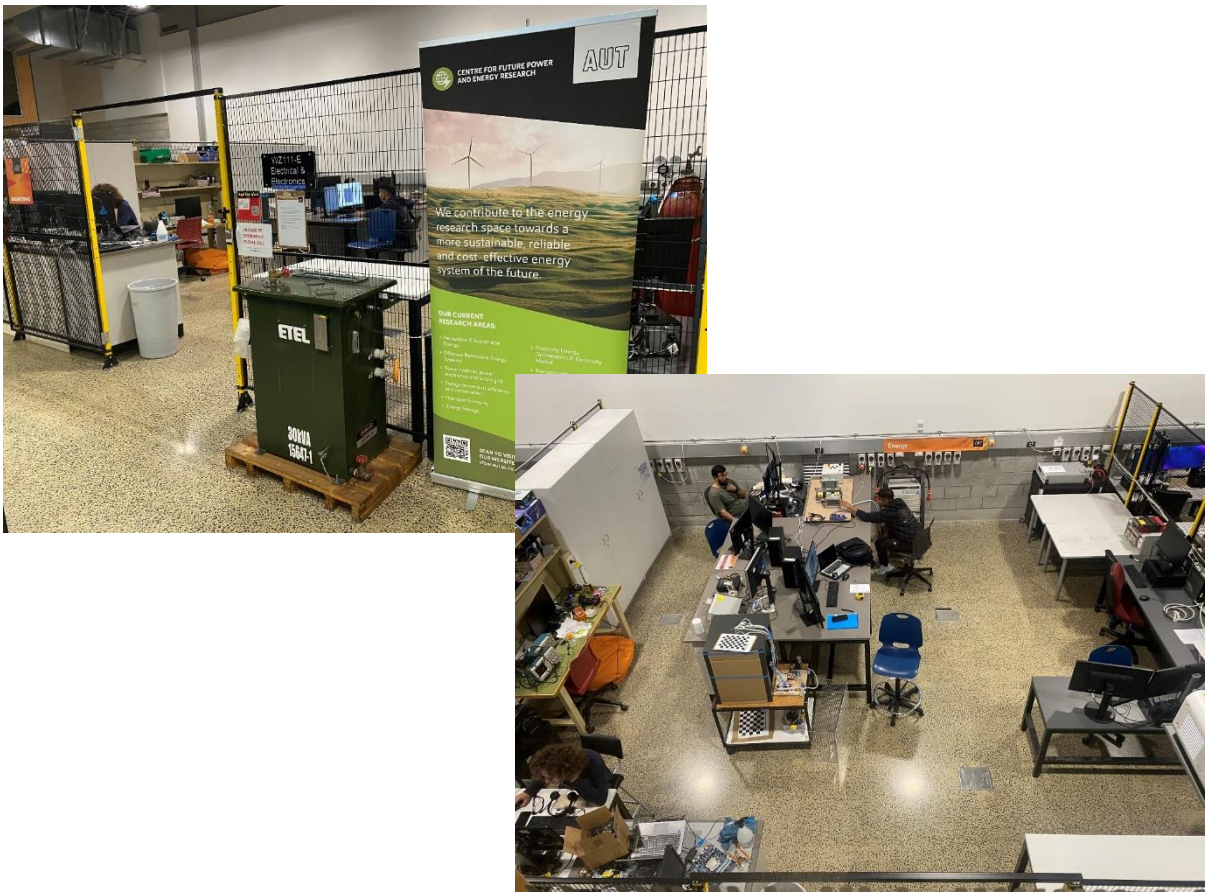
9.00 – 9.45

Time: 8:30 – 9:00 AM

Join us for a guided tour of the AUT Power Systems Research Laboratory, where cutting-edge research in electrical and power engineering takes place. This tour offers a unique opportunity to explore the state-of-the-art facilities, gain insights into ongoing research projects, and learn about the innovative work being conducted by our team.

During the visit, you will have the chance to:

- Observe advanced equipment and technologies used in power systems research.
- Understand how our laboratory supports groundbreaking studies in areas such as DC grids, renewable energy integration, and power electronics.
- Engage with our researchers and students to discuss their projects and potential real-world applications.
- This lab tour is designed to showcase the AUT Power Systems Research Laboratory's contributions to advancing the energy sector and inspiring the next generation of engineers and researchers. Don't miss this chance to witness innovation in action.



AUT Power System research laboratory

WS1, WS2 and WS3 facilities - UoA-City 405-628 Power Systems Lab 10.00 – 10.30

UoA Main campus laboratory

Tutorial: Hardware-in-Loop for Grid Interconnection

Dr Felipe Arraño-Vargas

RTS@UNSW, UNSW Sydney

9.00 – 10.30

Felipe Arraño-Vargas is an Engineering Early Career Academic Fellow at the School of Electrical Engineering and Telecommunications, UNSW Sydney. He is also a Research Fellow and Lecturer with the Real-Time Simulations Laboratory (RTS@UNSW).

His research focuses on power system digital twins, real-time digital modelling and simulation, synthetic grids, and the grid integration of renewable energy resources and energy storage systems.

This presentation will cover how real-time simulations and hardware-in-the-loop testing are becoming critical for analysing the grid integration of inverter-based resources while accelerating their secure deployment.

UNSW SYDNEY
Real-Time Simulations Laboratory
RTS@UNSW

Industry talks and discussion with Dr. Satpathi and Dr. Lamara.

10.45 – 12.00

Facilitated by Dr. Hamish Avery and Prof. Nirmal Nair

Dr Kuntal Satpathi - American Bureau of Shipping

Modelling and Simulation to Support Maritime Decarbonisation

Kuntal Satpathi is a Senior Engineer at ABS in the Technology Pacific Division, focusing on vessel electrification, energy systems modeling for green shipping corridors, and the carbon capture value chain. He earned his PhD. in electrical engineering from Nanyang Technological University, Singapore, in 2019. With over 10 years of experience in various segments of the energy industry, Kuntal began his career working on a 1000 MW mega power project in India as a DCS operation and electrical engineer. He then spent 7 years in R&D, working on the operation and protection of emerging DC marine vessels and research projects for Rolls-Royce Power Systems. Most recently, he served as a pre-sales consultant with Energy Exemplar, providing bespoke solutions to diverse stakeholders in the energy industry, including generation companies, distribution companies, and renewable energy developers, with use cases in portfolio optimization, nationwide decarbonization planning, investment analysis, and resource adequacy.

Dr. Tarek Lamara - Senior R&D Expert, Sécheron SA. Switzerland

Trends and Evolution of DC Circuit Breakers in Railway Systems and DC Micro-Grids

Tarek Lamara received his M.S. and Ph.D. degrees in Plasma physics and Optoelectronics from the University of Lorraine, Nancy, France, in 2000 and 2004, respectively.

His research focused on the optimization of high-power pulsed microwave plasmas and magnetron sputtering for various thin-film processing.

In 2006, he joined ABB Corporate Research in Baden, Switzerland, where he worked as a scientist and project manager in medium-voltage (MV) switching technologies, specializing in vacuum interrupters and power semiconductors.

His research work covered vacuum arcs investigation and plasma diagnostics, electromagnetic and electro-thermal simulations, and vacuum interrupter design optimization.

In addition to his technical contributions, he managed several multinational R&D projects and coordinated research activities with the business unit.

Since 2013, he has been a Senior R&D Expert at Sécheron SA, a global leader in railway electrical safety equipment, where he also oversees intellectual property strategy and innovation.

He is involved in the development of new generation of MV AC circuit breakers and switchgear and managing the new development of innovative hybrid DC circuit breakers and contactors.

Actively involved in circuit breaker research since 2006, he is a co-inventor of 20 patents and has co-authored over 40 international scientific publications.

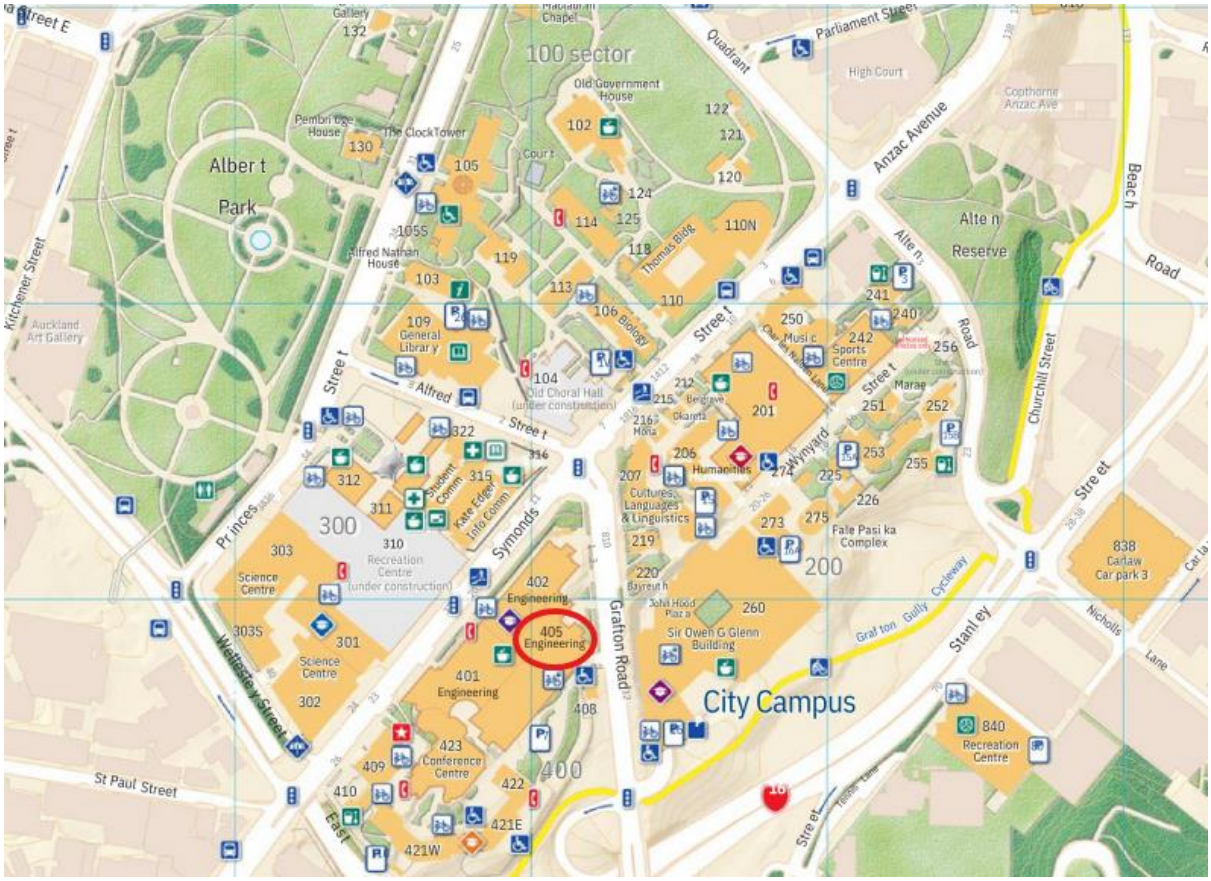
He is a member of IEEE society and a regular reviewer for “IEEE Transactions on Plasma Science” and “IOP Plasma Science and Technology”, and a member of Electro-Suisse, the local representative of CIGRE organization (International Council on Large Electric Systems).

He is also a full member of Current Zero Club (CZC), an international research group on current interruption phenomena in power switching devices

Location: 405-470, Faculty of Engineering (entrance at 20 Symonds Street), University of Auckland

https://www.auckland.ac.nz/assets/on-campus/our-campuses/campus-maps/city-campus-map.pdf

Alternative entrance at 5-7 Grafton Road from across the Business School car park



Parking:

Street parking on Princes Street with AT charges:

OGGB UoA business school building $25 per day