List of IC@N Research Projects and Supervisors

Energy Research Institute @ NTU

Name of Supervisor	Research Project Description
Professor Subodh Mhaisalkar subodh@ntu.edu.sg	**Lower dimensional perovskites based on tailor-made cations for optoelectronics** Hybrid organolead halide perovskites have emerged as a promising material for non-silicon based thin-film photovoltaic technology and recently reached solar-to-electrical power conversion efficiency above 22%. However, there are serious hurdles remaining for the widespread use of perovskite solar cells , for example, the sensitivity of perovskite materials to moisture, which leads to its rapid degradation and hence a short device lifetime. One of the methods to improve stability is the development of lower-dimensionality layered perovskites derived from their 3D counterparts by increasing the distance between the interconnected inorganic sheets with organic cations. Such multifunctional organic cations can enable hydrogen or halogen bonding between the organic cation and inorganic framework to reduce the band gap while increasing the stability and charge carrier mobility. This project will focus on the design of new cations to establish strong bonding with inorganic lattices (H/halogen bonding) and higher structural robustness. In-depth studies will also be undertaken to understand the relationship between materials composition, structure, and properties to facilitate the device integration based on these materials to deliver transparent perovskite solar cells with high efficiency and long term stability.
	Perovskite nanostructures for light emitting devices Organic-inorganic hybrid halide perovskite materials have already revolutionized solar cell applications. The certified power conversion efficiency of solar cells based on CH3NH3PbI3 and derivatives have attained a record value of over 22% within a short period. Concurrently, the potential for perovskites to transform the field of light emission has also been demonstrated. The focus is now expanding to encompass the fabrication of perovskite nanoparticles (NPs) to achieve color tunability and enhanced photoluminescent quantum yield (PLQY). This project aims the morphology controlled synthesis of perovskite nanoparticles (NPs) with enhanced quantum yields by confining charge carriers, passivating non-radiative recombination sites and improving processability via careful crystal engineering for the cost effective development of perovskite based light emitting materials suitable for large area processing.

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Design and Development of 10 MW Medium-frequency transformer based resonant power conversion

Medium frequency high power transformers has become a promising field of research along with their functions of galvanic isolation, and voltage transformation in all high power converters typically used in traction power systems, offshore wind plant power converters, and solid state transformer based distribution system grids. With cost and space savings along with high efficiency and thermal management being critical technical challenges to be addressed on the system level, the need to develop a Monolithic High Power Medium Frequency Transformer for 10MW rated converter and experimental validation of the design methods assumes significant importance which need to be demonstrated at acceptable power levels before scale up. Equally important is to computerize the design, in order to analyze multiple combinations of layouts and geometry, to optimize the medium frequency related winding losses and core losses and design a robust insulation and thermal packaging in order to have a capable design to withstand harsh environments such as offshore wind generation. Detailed experimental testing and followed up with FEM analysis is essential to solve the multi-dimensional electromagnetics and thermal issues and ensure the overall system is efficient and reliable to handle such high voltage and high power. The project envisages the above technical challenges and the developed tool endeavors to analytically solve the complex equations in 1D with parallel analysis using 2D and 3D FEM analysis. The electric field behavior analysis is ongoing to verify the voltage distribution across the various parasitic capacitances and magnetic field behavior analysis of the designed transformer to ensure operation of core below saturation level and also check the leakage inductances are as per and within desired specifications. A Plecs/Matlab based simulation circuit for DC-DC Series resonant converter circuit is modelled to simulate the high power medium frequency transformer performance in circuit operation of resonant converter and check the electromagnetic response under high rising square wave voltages with high harmonic content

On demand Mobility solution for Connected Autonomous Vehicles

Autonomous vehicles could serve as new mobility modes to offer customized and demand-responsive transport services to solve the first and last mile problems. To cater to the projected high volume, high frequency transport requirements in a given space and both by public segment as well as by the logistics industry, it is apparent that existing modes of transport will not be feasible. One way to resolve such rapidly changing mobility system is to introduce varying stages of autonomy in various modes of transport. NTU's forefront research is to introduce autonomous transportation model related to both public transport and industry. The primary focus is to methodically design, develop and test an integrated set of sensors, controllers, and software to develop a robotics kit that will be used to convert existing vehicles to an autonomous vehicle. The kit provides all features

	currently provided in AVs through an external system mounted and integrated into the vehicle with a complete set of sensors sending all data required by the autonomous driving system. Trajectory mapping, positioning, and localization, vehicle controls, powertrain to communication links and HMI services are the key features embedded in the modular kit. Such competence of integrating multiple sensors with a power train will enable to retrofit a given set of sensors on an existing vehicle platform to convert a level-0 vehicle-based transport solution to a Level-V vehicle-based solution. In addition, a cloud based supervision software is designed to integrate and simplify resource management and improve cost-effectiveness, while enhancing service quality and productivity of the entire autonomous fleet operation. Predictive analytics and data visualization tool in the cloud control center enables location based services for route optimization and for requesting the vehicle on demand. Other features like locating the parking lot, commanding the vehicles for new operations and self-auto charging, route scheduling form the critical aspects of design and validation. The infrastructure to control, monitor and guide the entire fleet of self-driving electric vehicles and development guidelines and a risk mitigation strategy to be used in the development of autonomous are being addressed in the R&D focus.
Dr Koh Liang Mong ELMKOH@Ntu.Edu.Sg	**Application of Energy Storage System in Photovoltaic System** Solar Power Generation Offer Carbon Dioxide Neutral Electricity But Also Present Some Integration Difficulties For Energy System Operators And Planners Due To Intermittent Power Output. To Smooth Out The Intermittency Of Solar Energy Production, Electrical Energy Storage Technology Will Become Necessary. In Order To Increase The Solar Energy Penetration With Appropriate Reliability, Energy Storage Systems Should Be Introduced That Could Technically And Economically Be Used In Association With Solar Photovoltaic Energy. Photovoltaic Systems Combined With Megawatt Energy Storage System Can Play A Role In Achieving More Economical Operation Of The Electric Utility. In This Project, Students Will Have To Check, How Energy Storage System Can Prevent The Intermittency Of Solar PV System. Students Will Also Have To Work On Energy Storage System To Check That How Can It Help In Terms Of Market Interactions. Student Will Have To Work With ETAP Or Equivalent Power Engineering Software.
Dr Narasimalu Srikanth nsrikanth@ntu.edu.sg	**Smart Pollution monitoring sensor system** In the modern world, diesel vehicles have become an integral part of human life for easy and quick transportation. But diesel-powered vehicles account for nearly half of all nitrogen oxides (NOx) and more than half of all particulate matter (PM) emissions in Singapore. NOx and Particulate matter may irritate eyes, nose, throat, and lungs, contributing to respiratory and cardiovascular illnesses and even premature death. Hence, it is essential to monitor the emissions of

	NOx and PM emissions of various diesel vehicles regularly in order to perform vehicle maintenance or replacement of vehicles in case of worst case. Thus, the main objective of this project is to design a compact sensor system and identify suitable algorithms based on machine learning methodology for real-time monitoring & data analytics to identify the right metrics of NOx and PM emissions.
	Aerofoil studies towards Tidal In-stream energy system Marine Renewable Energy has been developing at an accelerating pace. Although the Tidal In-Stream Energy (TISE) Industry has reached pre-commercial stages and will soon be deployed in commercial scales, there is need for innovation especially if the Levelised Cost of Energy (LCOE) is to be competitive with conventional electrical power generation from fossil fuels. While much of high energy locations, associated with high speed tidal flows, such as Europe, USA, Canada, Northern Asia are easily reached and addressed, the tropical markets (such as India, Southeast Asia) for lower-tidal-velocity distributed generation, particularly for remote-island applications are not met. In this project focus will be in the selection of nature inspired aerofoils towards in-stream tidal turbine system. The project will utilize Computational fluid dynamics tools to study the aerofoil's lift and drag behavior and compare against experimental characterization results towards adopting into an actual tidal energy blade for maximum energy energy harvest in a low flow tidal flow condition.
	Seawater Based Cooling of Data Centers Data centres are centralized locations where computing and networking equipment is concentrated for the purpose of collecting, storing, processing, distributing or allowing access to large amounts of data from industries. Data centres consume high levels of energy to power the IT equipment contained within them, and extract the heat they produce. This project will focus to evaluate the use of seawater based heat exchangers by allowing Data centres to operate in a shallow water setting in a coastal site and ensure maximum reliability in thermal management to increase the energy efficiency and lowering the PUE requirements. In order to achieve it, the project task will focus to identify the thermal management and heat exchanger physics under seawater cooling condition and evaluate the effects of environmental variables such as the occurrence of biofouling and corrosion on the thermal management mechanism of the heat exchanger and focus on the methods to ensure the consistency of the heat exchanger performance.
Dr Kong Xin xin.kong@ntu.edu.sg	**Next Generation Gallium nitride (GaN) based power electronics** Gallium nitride (GaN) is an emerging semiconductor technology with superior characteristics for next generation power electronics. This includes the ability to operate at higher switching frequency, lower losses, smaller footprint, and others.

	The candidate will contribute towards the development of a high efficiency GaN power converter for Energy Storage System applications. In this project, the student will be involved in three areas: the high frequency magnetic component design using multi-physics modelling and simulation tools, thermal management of the power circuit and design verifications through Printed Circuit Board (PCB) layout and testing.
Alex Chong alex.chong@ntu.edu.sg	**Standards Based Procedures for Testing and Certification of Stationary Electrical Energy Storage (EES) Systems** Electrical Energy Storage (EES) systems have become increasingly important to enable greater renewables penetration and grid stability. Multiple standards exist for certification of EES systems for stationary deployments for grid applications. They include IEC 62933 series, IEC 62485 series, IEC 62619, UL 1973, UL 9540, and TR 77. The standards broadly cover various aspects such as planning requirements, system performance or functionality and safety considerations and features. The candidate will be working at the Experimental Power Grid Centre (EPGC), a MW-scale grid facility based in Jurong Island, Singapore. A detailed comparison of the test clauses and mapping of their similarities and differences is required to identify how these standards overlap and areas where they are complementary. Subsequently, the detailed test methods or procedures can be proposed and optimized to satisfy the requirements of each test clause.
Prasanna IV prasannaiv@ntu.edu.sg	**Mutli-microgrid modelling and studies** With increasing deployment of distributed energy resources and emergence of microgrids in the power systems, the topics surrounding multi-microgrids modelling is becoming important. The candidate will be working on the Renewable Energy Integration Demonstrator- Singapore (REIDS) testbed on Pulau Semakau. REIDS is a multi-microgrid setup involving MNCs such as Engie, EDF and Rolls-Royce. Potential R&D topics include the development of next-gen grid management platform that enables multi-microgrids interoperability, cyber-security, dynamic system optimization via analytics and computational intelligence and energy exchange and trading.