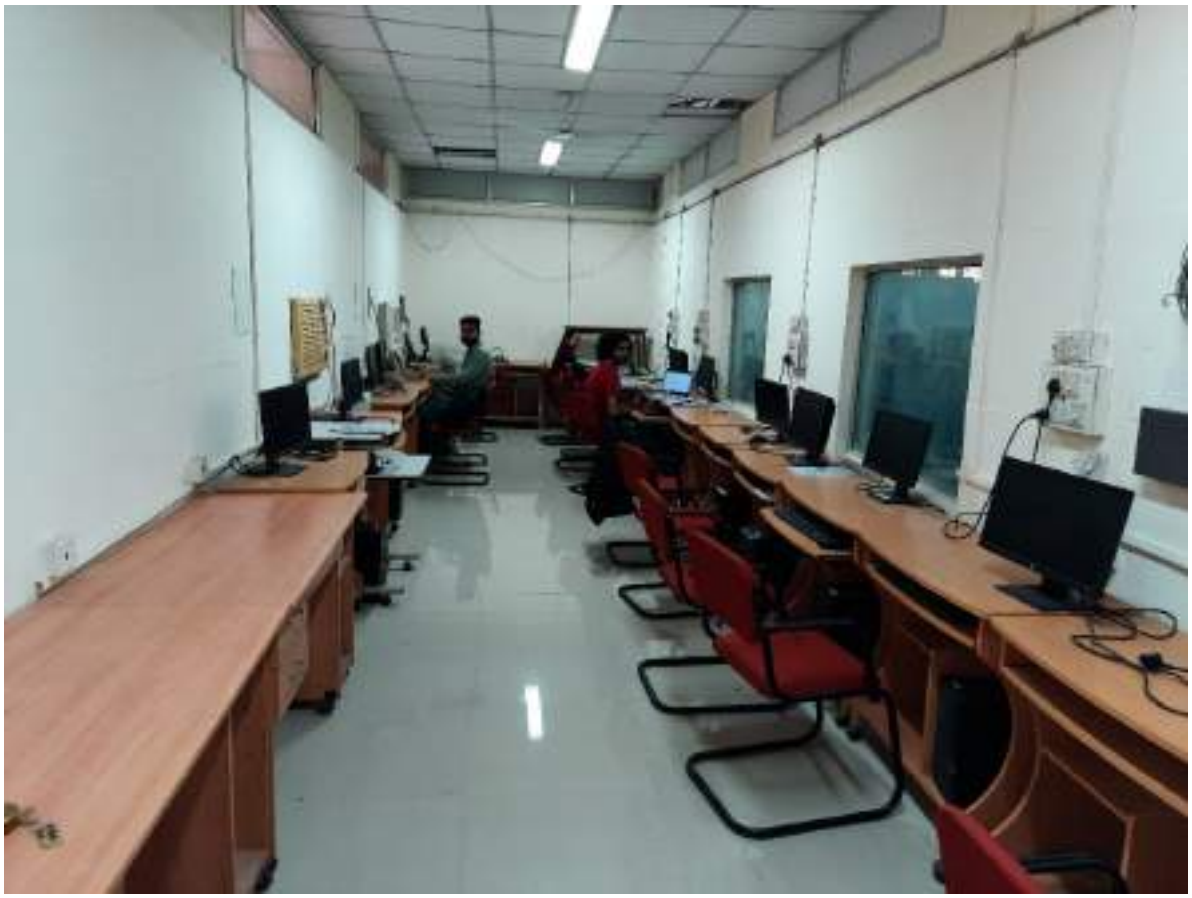
Electrical Machines and Drives lab

Workspaces in the EMD lab

Electrical machines and drives (EMD) lab is unification of Electrical machines, Power Electronics and Electric drives. It has primarily seven workspaces where students perform experiment and research activities. This include Research workspaces, Machines lab, Drives lab and PG simulation lab.

Drives Lab

PG Simulation lab



Machines lab

Research workspaces

Sponsored Research projects

Project Name: Prototype development of Fuel Cell and Photovoltaic Based Innovative Hybrid DC Power Pack for Remote Applications
Funding Agency: Science and Engineering Research Board
Total cost of the Project: ₹ 38.10 Lakh
Project status: Ongoing (w.e.f. 25.03.2021)

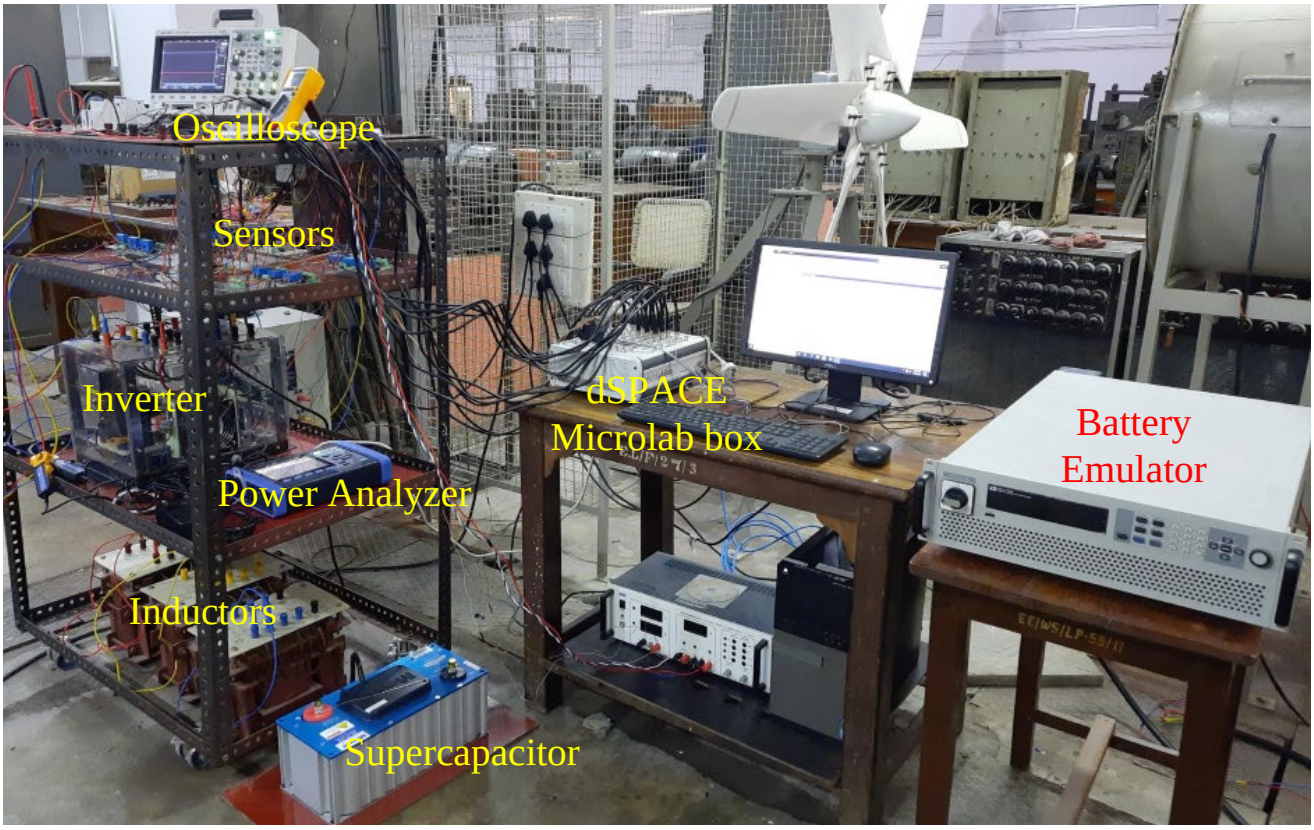
This project proposes a merger between Photovoltaic and Fuel Cell technologies as a solution to remote energy needs. The main purpose of the proposed project is to design a clean and stand-alone power generator for isolated sites using renewable energy sources. The idea is to combine Photovoltaic Panels (PVs) with Fuel Cell (FC) to build an uninterrupted power generator. 3 kW PV based power will be improvised by using a suitable dc-dc converter at the output of PV panel. Design and development of an efficient 3 kW fuel cell emulator with the help of battery and suitable converters. The integration of PV and FC based system will be done to form a hybrid power pack. The hardware implementation of the hybrid system will be carried out and it will be tested to validate its efficacy for rural applications and remote applications.

2 kW Fuel Cell Based Power Generator

Project Name: Design and Analysis of Linear Induction Motor Drive for Electromagnetic Aircraft Launching System (EMALS)
Funding Agency: DRDO, R&DE, Pune
Total Cost of the Project: ₹ 30 Lakhs
Project Duration: February 2020 to August 2022

The aim of the project is to provide Design Analysis of Double-Sided Linear Induction Motor (DSLIM) drive for Electromagnetic Aircraft Launching System for occult launching and also for on board ship launching. The whole project requires designing DSLIM with impulse three phase power, complete mechanical design, thermal studies and EMI / EMC compatibility. It requires three phase Variable Voltage Variable Frequency (VVVF) power of hundreds of MW for a launch time of around few seconds during which mass of aircraft is required to be propelled at around 100 m/s speed in a distance of less than 100 m; the application of electrical plugging releases the aircraft for propulsion. The project Principle Investigator (PI) Prof R.K.Srivastava, Electrical Engineering, Co- PI Dr O P Singh, Mechanical Engineering and Dr S Bhattacharyya, Electronics Engineering are dealing with different aspects of the project.

Project Name: Virtual Synchronous Generator for Microgrid Applications
Funding Agency: Science and Engineering Research Board
Total Cost of the Project: ₹ 45.53 Lakhs
Project Duration: April 2019 to March 2022



Developed Hardware prototype of Virtual Synchronous Generator for Microgrid Applications

Project Name: Prospects of power converters for Integration of Electric vehicle charging stations with the existing Electric distribution system in India
Funding Agency: MHRD-SPARC
Total Cost of the Project: ₹ 49.78 lakhs
Project Duration: July 2019 to March 2022

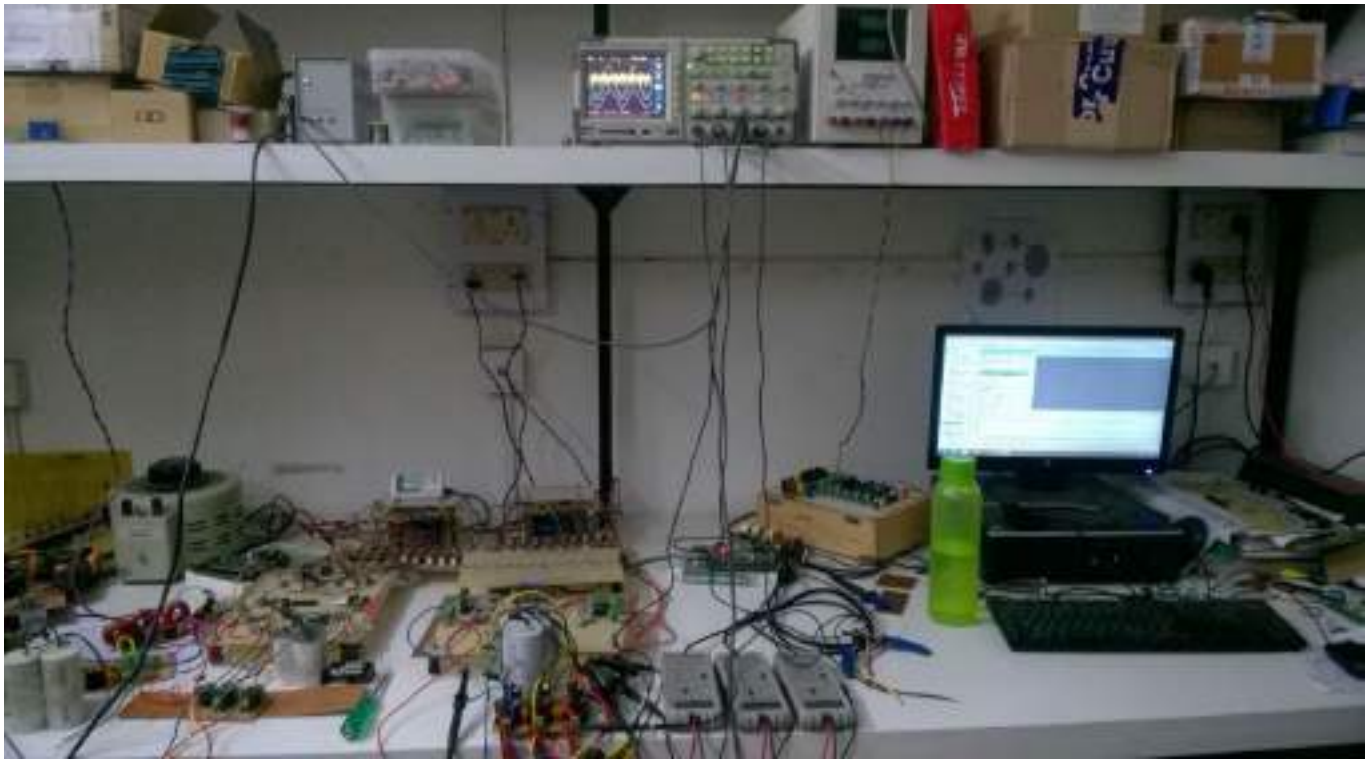
The aim of the project is to propose a feasible solution for electric vehicle charging stations at power distribution level with adequate utilization of the existing infrastructure. For this a DC microgrid is considered to be added on top of the existing AC utility. Under this scheme Prof. Richard McMahon from University of Warwick and Dr. Teng Long from University of Cambridge were expected to visit IIT (BHU), and stay here for a certain duration. During this period, they planned to interact with students and faculty of IIT (BHU) to share their research experience and provide expert opinion for the growth of EV charging infrastructure in India. An online symposium was conducted under this project which is found to be very useful for the Indian research community. Student exchange is also planned in this project.

Project Name: Modelling and Simulation of Linear Drive for Propulsion Application
Funding Agency: RCI, Hyderabad
Total Cost of the Project: ₹ 10 Lakhs
Project Duration: July 2018 to June 2020

The aim of project is to design analysis of electromagnetic propulsion using short length primary - Single Sided Linear Induction Motor (SLIM), Double Sided Linear Induction Motor (DSLIM) and Tubular Linear Induction Motor (TLIM) for electromagnetic propulsion of mass of few kg at the known exit velocity for mass propulsion applications.

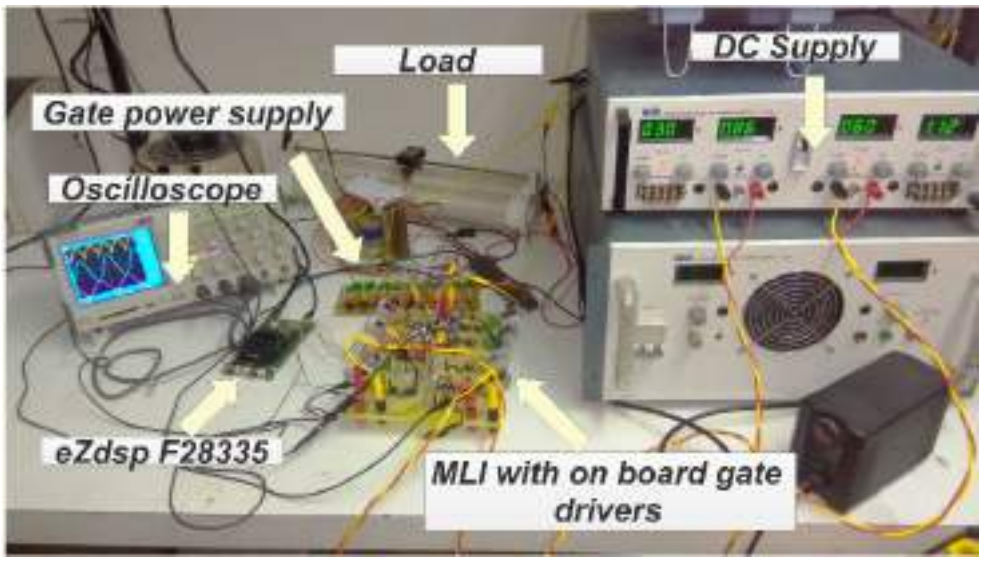
Project Name: Robust Predictive Controller for High Power Density Electric Drive
Funding Agency: IIT (BHU)
Total Cost of the Project: ₹ 15 lakhs
Project Duration: 2017 to 2018

Three phase AC-AC conversion is required in wind power generation to deliver safe and clean energy to distribution systems. High voltage gain, power handling capability during fluctuations, to maintain power quality, load power factor and robustness are key parameters in selection of converter. A new high gain ultra-sparse matrix converter is developed having these specifications to deliver power in efficient manner. Real time disturbances such as step change in load demand, power fluctuations and disturbance in input supply are emulated to test the effectiveness and potentiality of the converter.



Project Name: Design, development and performance analysis of silicon carbide converter for aerospace application
Funding Agency: DST-SERB
Total Cost of the Project: ₹ 26.77 lakhs
Project Duration: 2013 to 2017

This project was focused on improving the energy efficiency by employing advanced power electronic converters using SiC power devices. The power electronics inside aerospace operates in a harsh environment of high temperature. To operate converters using existing silicon devices safely, complex cooling arrangements, such as a special low temperature cooling circuit, are needed. The SiC devices can operate at an increased power density even when cooling is considerably reduced. In addition, the advantages of higher switching speed of SiC devices will enable the complete removal, or at least a significant reduction in size, of the filter that is currently required to limit ripple current in the motor at the switching frequency, with obvious cost and weight benefits. Due to fast switching behaviour exhibited by WBG devices, EMI is generated which affects the gate driver circuit operation. A current source gate driver is developed achieving trade-off between switching speed and EMI in driving WBG devices. This is integrated and tested to drive SiC based MLI converter.



Project Name: Development & Evaluation of Low Cost LIM Propelled Rail Metro System
Funding Agency: AICTE
Total Cost of Project: ₹ 10 Lakh
Project Duration: 1997-99

Low cost LIM propelled Rail Metro system was developed by Prof (Late) S N Mahendra. It was revealed that though LIM has several drawbacks in its operation but application of LIM in metro reduces the height of train, suitable for metro applications, this also reduces the cost of tunnelling, cost of ventilation and air conditioning required in tube railways. The full-scale Linear Induction Motor (L.I.M.) capable of carrying 24 persons, 70 m broad gauge rail test track. The system was operated using Variable Voltage Variable Frequency power supply. The Principle Investigator was Prof (Late) S .N. Mahendra and Co-PI were Prof M. Bhattacharyya, Prof G Rajshekhar, Prof T . Srinivasan and Sri R. K. Srivastava .The system was also sent for demonstration at Indian Railways Electrical Engineering Institute (I.R.E.E.N.), Nasik during 2007-2012


MALAVIYA CENTRE FOR
Development & Evaluation of
LIM Propelled Rail Metro System
Funding Agency: MHRD / AICTE

Project Name: Linear Induction Motor Propelled Material Transport System
Funding Agency: Ministry of Human Resource Development, Govt. of India (MHRD)
Total Cost of Project: ₹ 10 Lakh
Project Duration: 1994-96

Broad-gauge model of Single Sided Linear Induction motor propelled model for material transportation was developed by Prof (late) S N Mahendra in 1995. The machine was tested on 70 m track which has secondary aluminium backed by iron, stator was mounted on a bogie which was 1 m meter SLIM having six pole linear induction motor with 440 V three phase supply. The power to moving train was provided by conducting three phases overhead running cable. The Principle Investigator was Prof (Late) S .N. Mahendra and Co-PI were Prof M. Bhattacharyya, Prof G Rajshekhar, Prof T . Srinivasan and Sri R. K. Srivastava.

Project Name: Surface Linear Induction Motor Traction model for Future Transport
Funding Agency: UGC
Total Cost of Project: ₹ 6000
Project Duration: 1978-82

In year 1978, Prof (Late) S N Mahendra had built up 15:1 Oval shape bullet train using SLIM (Single Sided Linear Induction Motor) propelled 33 m rail track with technical support from Diesel Locomotive Works (DLW), Varanasi and UGC grant of Rs 6000/=. It utilizes three phase Single Sided Linear Induction Motor which collects three phase power from three slip rails – three carbon brush arrangements. The model was demonstrated at Railways Pavilion during India International Trade Fare (IITF), New Delhi several years between 1985-90. Similarly, Overhead working system and ropeways demonstrate the application of LIM technology.


INSTANT LAB

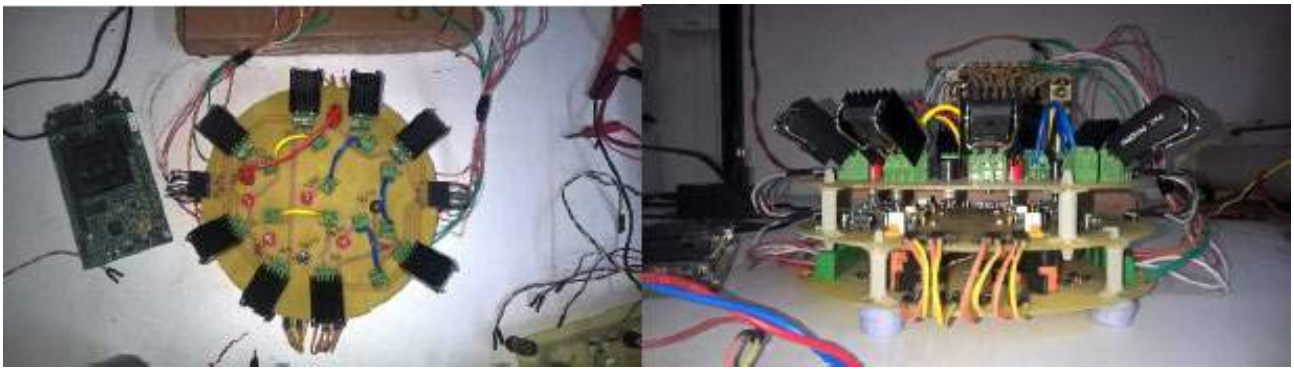
Research projects

Project name: Magnetically coupled Dual stator five phase PMSG for wind power application

Dual stator single rotor PMSG (DSFP-PMSG) has a potential to offer high power density, light weight, high efficiency and multitasking features. It consists of two stators namely outer and inner stator used for the housing of double layer fractional slot winding and single cup type rotor. The cup type rotor comprises an iron core sandwich with two sets of eight poles magnets arrangement. This PM arrangement offers a magnetically coupling between these two sets of magnets which offers high magnetic flux densities in the both of air gaps namely inner and outer air gap. The power density and reliability can be further improve using multi-phase (above than 3-phase) system.

Project name: High power density multilevel inverters

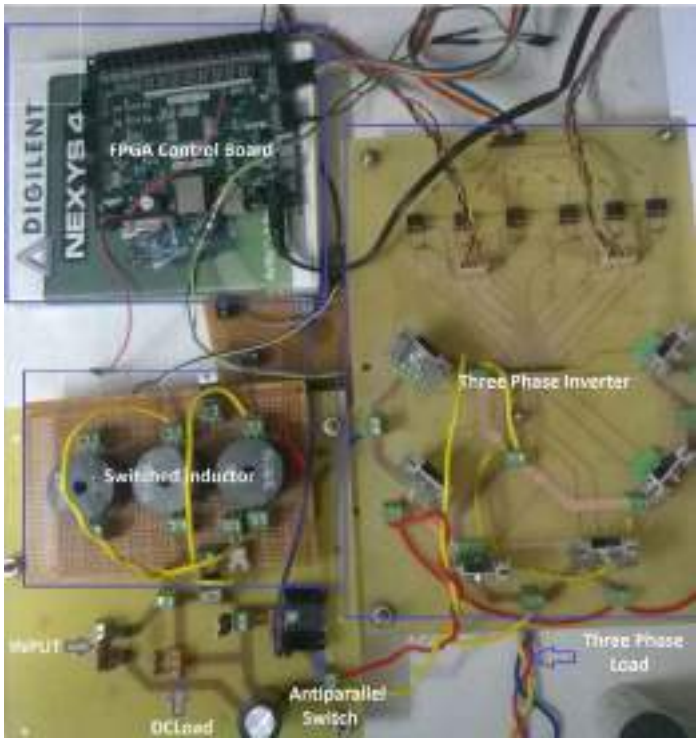
Multilevel inverters (MLI) shows promising signs in many applications due to its less harmonic content present in its output hence requiring small filter. This is achieved at the cost of complex control technique as the number of switches in MLI is more. A modified multilevel DC link inverter (MMLDCLI) is developed with reduce device count as compared to conventional MLI, for achieving same number of levels. A 7 level inverter is developed to with 6 switches. A novel low frequency simplified gate pulse driving technique is also proposed to further simplify the control technique implementation. Experimental setup of MMLDCLI.



Project name: Single stage Hybrid Converters simultaneously producing AC and DC output

Hybrid converter for supplying DC and AC load is an interesting solution as compared to dedicated converters. The better efficiency, compact structure and immunity to electromagnetic interference are

the features of Hybrid converter as compared to dedicated converters. However, existing Hybrid converters have poor voltage gain and have improper operation in wider duty cycle operation. To overcome later difficulty, we have proposed modified boost derived Hybrid converter which can function in wide duty cycle operation and in standalone operation. Still, the gain of the converter was restricted. To improve this, a L- ZSI derived Hybrid converter is proposed which has better gain along with all the features of modified boost derived Hybrid converter. To extract maximum gain, L-ZSI Hybrid converter is operated in discontinuous current mode.



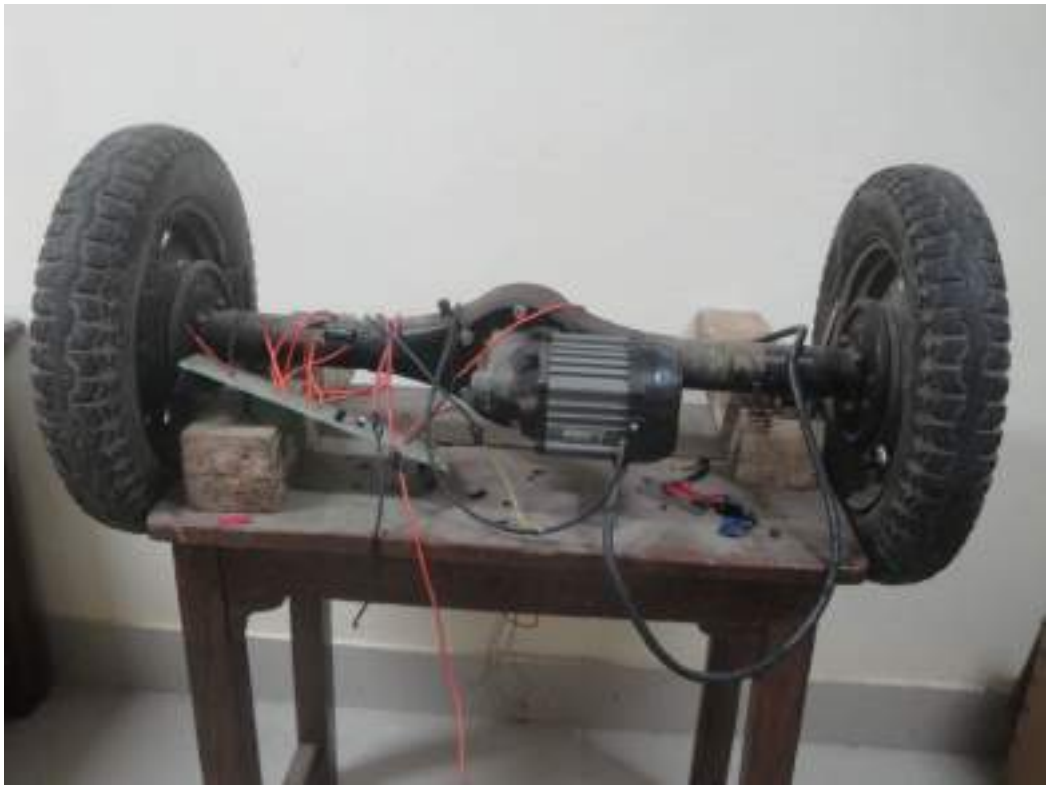
Project name: Photovoltaic and Wind Energy Based DC Microgrid

A blower and a 200 Watts wind turbine is mounted on a mechanical frame for simulating wind power generation for laboratory indoor use. A 200 Watts solar panel with stand. The panel is equipped to take output of the wind turbine. Research is being carried out to design and develop a prototype of photovoltaic and Wind based hybrid DC Microgrid.

Project name: Design and Development of PM BLDC Motor Based Electric Drive Train for Light Electric Vehicle

The research aims at design and development of efficient electric drive train for PM BLDC motor based

electric drive train. The major focus is on design and fabrication of converters with proper controller for regenerative braking of the motor.



Project name: Performance Improvement and Torque Ripple Mitigation of Permanent Magnet BLDC Motor

Study of closed loop speed and torque-controlled BLDC drive – (PWM current controlled drive, Hysteresis current control drive, deriving transfer function of BLDC closed loop system, Design of current and speed controllers). Study of Torque ripple analysis and its mitigation techniques- (study of causes of torque ripples of different types, study of commutation phenomena and commutation torque ripple, comparison of existing torque ripple mitigation techniques, design of a new slope regulator based advance angle control for torque ripple mitigation). Field oriented controlled of BLDC motor – (study of d-q axis reference frame model of BLDC motor, design of vector controlled closed loop BLDC drive for performance improvement, application of SV-PWM for FOC of BLDC motor, Comparative analysis of FOC with scaler control). Study of modified Vector control - (Study of non-conventional FOC for trapezoidal flux BLDC machines, Modified parks transformation for Torque ripple rejection in BLDC machine, A new flux harmonic rejection technique for FOC of BLDC drive, study of a current harmonic injection technique for torque smoothening). Multilevel inverter fed BLDC drive – (Study of Different multilevel inverter topologies, Study of novel MLI with reduced switch count, performance investigation of CHB fed BLDC drive with SV-PWM based vector control, Design and study of asymmetric seven and nine level CHB inverter.

Project name: Performance Analysis of a Nine Level Hybrid Nested Neutral Point Clamped Multilevel Inverter with Induction Motor for Electric Vehicle Application

The nine level is obtained using 5 level NNPC and a half bridge in each phase with separate dc voltage sources. The hybrid NNPC consists of 12 switches per phase in which 8 switches are used to produce the five levels(0, Vdc/4, Vdc/2, 3Vdc/4, Vdc) and 4 switches work as a polarity generator i.e., the positive voltages are converted into negative levels(-Vdc/4, -3Vdc/4, -Vdc/2, -Vdc, 0) as per the requirement. It consists of 4 capacitors of which 2 are dc link capacitors and the other two are flying capacitors. Flying capacitors require voltage balancing by using the redundant states. PWM technique used is Phase Opposite Disposition.

Project name: Design Modifications in Single Tooth Winding Double Stator Switched Reluctance Motor

for Torque Ripple Mitigation

Project name: Design and Development of Rectenna with Power Management Circuitry for Satellite Solar Power Station

The transformation of the energy sector is looking for clean energy technology that is also suitable for baseload power generation. Terrestrial solar energy has many obstructions, so solar power from space without any hindrance has higher priority for adoption, and it is suitable continuous energy supply in the future. Due to its high estimated space launching cost, it was suspended in earlier attempts, but Technological advancements and research are going on worldwide, and its practical implementation could be possible by 2030. For the feasibility of satellite solar power station (SSPS), High power wireless transmission for large distance via Microwave is the key issue, and many techniques have been developed. As SSPS total system cost reduction is desirable, and therefore an economic model of the system is required where it has interrelated parameters that can be optimized for the high efficiency and cost-effective performance. Furthermore, harmonic harvester Rectenna integrated power management circuitry for improving RF-DC power conversion efficiency is developed. The circuitry is designed for battery charging or energy storage application; resistance emulation method is used to realize a matching load resistance at output terminals. A technique for harvesting near maximum output power from the dual rectifiers (fundamental and harmonics) independently. Also, it delivers the combined maximal power to the energy storage cell. The power management module based on dual input buck-boost converter with simple open-loop control is utilized.

Project name: Battery and Supercapacitor based Hybrid Energy Storage system for Electric Vehicle Applications

Project name: Doubly Fed Induction Generator for Wind Energy Conversion Systems

Project name: Multi-phase drive for propulsion system for electric vehicles

Multi-phase machines offer higher torque and power in the same machine frame along with improved reliability. The research focuses on designing and developing a compact converter for multi-phase drive. All the 72 stator terminals of a 6-pole 3 HP motor have been brought out on a connection plate. This motor can be re-connected to be operated in 3, 6, 9, and 12-phase configuration based on the requirement. Machine windings of the machine will be utilized for fast charging purpose

Project name: Design and Development of a three-port converter for solar electric boat application

A three-port converter with two input port and a single output port is termed as dual input single output (DISO) converter. The same converter can also be operated in single input dual output (SIDO) mode based on the requirement. This research aims on developing a three-port converter with battery and solar panel on the input port and BLDC motor on the output. When solar power is available abundantly converter charges the battery and drives the motor operating in SIDO mode. When solar availability is limited both battery and solar PV supplies the propulsion drive operating the converter in DISO mode.

Project name: Energy Management System for Electric Vehicles

This research is focused on the energy management aspect of electric vehicles including both Vehicle-to-Grid (V2G) and Grid-to-Vehicle (G2V) modes. Both hardware set-up (power electronic controllers, computers with high data processing capabilities installed with controller design) and software (mostly data processing e.g. Python, MATLAB, LABVIEW, etc.) support for will be utilized for implementing and experimenting with latest energy management methods. Most advanced tools such as Artificial Neural Networks, (ANN), Deep Learning Methods, Block chains, Data Mining, have been included in developing the Energy Management System.

Major Equipment

Amplidyne-Metadyne

Single phase Induction motor

Pole changing Induction motor

Repulsion motor

Schrage Motor

Cascaded Induction motor

Permanent magnet synchronous motor

Switched Reluctance motor

Permanent magnet synchronous generator

Hysteresis Dynamometer

dSpace 1104

dSPACE Microlab box

TI DSP F28335

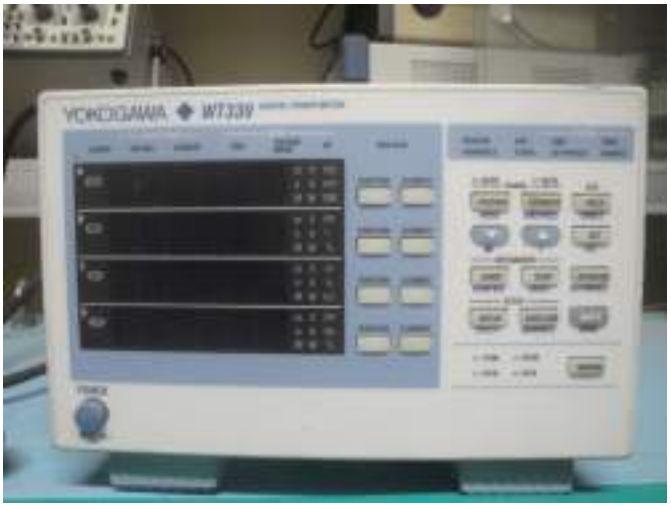
Spartan FPGA NEXYS 4

Ultra sparse matrix converter

Super Capacitor

AC/DC Electronic load

PV Emulator



Power analyser

PV simulator

Programmable AC/DC power supply

High voltage DC supply

PMSG test rig

Semikron converter