RENEWABLE ENERGY RESEARCH CENTRE

(Centre of Excellence)

Department of Electrical Engineering

RAJKIYA ENGINEERING COLLEGE, AMBEDKAR NAGAR (737)

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Renewable Energy Research Centre (RERC)

(Centre of Excellence)

Department of Electrical Engineering

Rajkiya Engineering College, Ambedkar Nagar

Akbarpur, Ambedkar Nagar – 224122, U.P

HIGHLIGHTS

❖ The 'Power & Energy Research Centre (Centre of Excellence) under Electrical Engineering Department at REC Ambedkar Nagar was initiated in the month of December, 2019 with the aid of TEQIP-III and is committed to engineer the future power engineering systems and to produce highly qualified and trained engineers by means of state-of-the-art research facility. Following are the Vision and Mission of the RERC:

Vision:

- To develop the Centre of Excellence in the domain of power & energy research.
- To integrate the expertise and the state-of-the-art tools at one place for providing quality & innovative research, testing, consultancy and training services in the field of electric power engineering & energy systems.

Mission

- To provide an inspiring platform to research-scholars academicians those working in power & energy domain, for disseminating research-based knowledge for the development of the Country.
- To provide training courses to students in the field of electric power engineering & energy systems.
- To provide cost-effective innovative solutions to the research problems in the field of electric power engineering and energy systems through the efficient use of advanced technology, state-of- the-art tools and methodologies.
- To provide outstanding testing and consultancy services to electric power & energy sector.

REC Ambedkar Nagar is Government funded Institutions under AKTU Lucknow having WAVECT Controller; it is a compact, versatile real time control prototyping system. Comprising of high end FPGA for fast computing and IO, dual core processor for control and communication, scalable embedded voltage and current sensors, large number of PWM outputs and high speed IO's, it is designed to address today's complex problems. Coupled with an easy and powerful model based development environment, push button device binary and configuration generation and a dedicated instrumentation software, it forms a complete control
prototyping solution. Controller-Hardware simulation facility in the domain areas of renewable energy, micro-grids, distribution networks, power electronics and electric drives.

Following the initiatives taken by Dr. Surya Prakash Singh and Dr. Sanjay Agrawal (Coordinator(s) , RERC); REC Ambedkar Nagar has installed with technical support of Entuple Technologies Pvt Ltd through their duly authorized representatives (under the aegis of industry-institute interaction activity) to the 'Power & Energy Research Centre' in order to extend not only the academic cooperation by way of sharing knowledge/capability in the concern areas for mutual benefits but also to conduct research, consultancy.

Renewable Energy

Renewable energy is important because of the benefits it provides. The key benefits are:

Environmental Benefits:
Renewable energy technologies are clean sources of energy that have a much lower environmental impact than conventional energy technologies.

Energy for our children's children:
Renewable energy will not run out Ever. Other sources of energy are finite and will someday be depleted.

The Economy:
Most renewable energy investments are spent on materials and workmanship to build and maintain the facilities, rather than on costly energy imports. Renewable energy investments are usually spent within the United States, frequently in the same state, and often in the same town. This means your energy dollars stay home to create jobs and fuel local economies, rather than going overseas.

Renewable Energy Lab

Relevance

Today's world is moving forward to the era of renewable energy. The reason why we are doing this is a known thing. But when this is happening in the front end, lots of things already happened at the back end. Corporate world and government already started their research to develop more efficient ways to extract energy, in other words maximum conversion rate. Lots of interest and attention is given to this field because of another possibility station oriented generation and transmissions is also possible like tidal power is mostly used in coastal area, wind power is used in hill stations, solar is used in villages with paddy fields and buildings with large area of rooftop. Being into different area it is obvious

that energy extractions are not going to be same. Even though the main power conversion remains same DC-AC with the grid the challenges are not the same. Fault conditions are different, transient behaviour varies according to operating timings (for some its seasonal for some its day for other it's may be night). Internal power conversion and control include both electrical and mechanical hand. Effect of environmental behaviour to each of the system also varies. So, we cannot conclude to the entire system into a one roof of energy harvesting. And day by day its demands is being increased that products that depends mostly on solar are quite common now, Industries are having their own power plants for the in house purpose. Many foreign governments are already running the idea if net power is given back to government, they will be paid.

All these scenarios points to the demand of good engineers researchers who can perform in the given field. The opportunity is high with this much demand in the earth we can't simply give away the fact that there is requirement for maintenance, supervision, research, better control system, power transmission, new topology converters, novel conversion idea, machineries etc.

This is where the importance of colleges and universities comes to play with a Renewable energy lab. All the students are coming out of the campus are now very much aware what is happening at the back end, where they should get into to perform their talent, which area they are fit to go in. they are no more afraid about what is going over there instead they will be curious what else they can. The knowledge they learned through lab experiment and research are pretty much similar in and its jus been performed in a scaled down version. The companies are looking for a person who already knows things, government need person who can deliver in much smarter way, the world these kinds of engineers.

(All the experiments with control mechanism are FPGA based control. All the power modulation or conversion mechanisms are IGBT based switching. All control, feedback, communication, signals are pre isolated, filtered and synthesized. All cablings are (power and signal) provided with proper grounding options are EMI shielding. All the required sensors, connectors required amplifiers and signal converters are provided no internal connections are required.)

DFIG based Wind Energy Emulator Module with Grid Synchronization

Specification	
❖ **Wind Emulator Machine Details.**	
220V, 2.5KW, 1500 rpm DC shunt Motor Coupled to 415V, 2.2 KW 1000 rpm 6 pole Three phase slip ring induction motor, 1024 ppr encoder included.	
❖ **Three phase IGBT based Inverter details (Rectifier + Inverter + Brake Chopper) (For DC Motor Drive)**	
❖ **Semikron IGBT based Converter (For RSC & GSC)**	
I/P AC Voltage: - 415 Volt	DC Voltage: - 600 Volt
O/P AC Voltage: - 415 Volt	O/P AC Current 30 Amp
Switching Frequency 20 kHz	Fundamental Frequency 50 Hz
Type of Cooling: - Forced Air	Ambient Temp: - 40 Deg
Duty Class: - Class I	

❖ WAVECT - FPGA Based Controller Details

It has Xilinx FPGA Zynq™-7000 SoC XC7Z020-CLG484-1with Dual ARM® Cortex™-A9 MPCore™ Which have capability Up to 667 MHz operation along with NEON™ Processing / FPU Engines.

Memory allocation in the board is given by 512 MB DDR3 and 256 Mb Quad-SPI Flash with Full size

Isolated Voltage (8) and current (8) sensors for feedback

PWM Card 3.3/5 to 15 V Level Shifting of 12x2 PWM Out with optical isolation.

Dedicated I/O with for encoder and Hall sensors with 5V supply and Differential noise reduction.

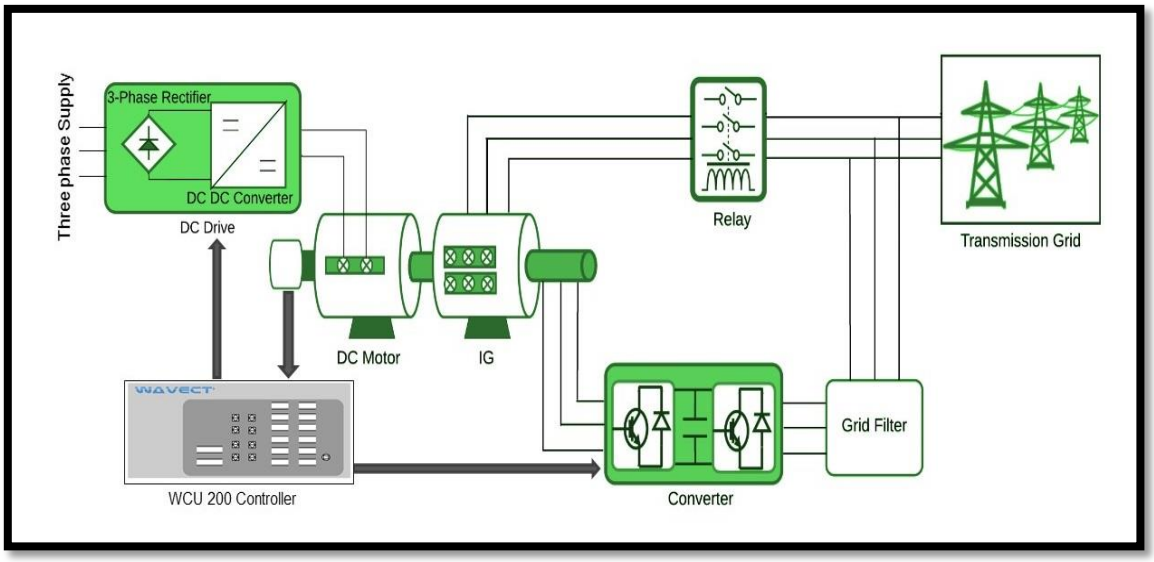

Fig- DFIG based Wind Energy Emulator Module with Grid Synchronization

Solar Energy Module with Grid Synchronisation

Specification
❖ **Three phase IGBT based Inverter details.** I/P AC Voltage: - 415 Volt — DC Voltage: - 600 Volt O/P AC Voltage: - 415 Volt — O/P AC Current 30 Amp Switching Frequency 20 kHz — Fundamental Frequency 50 Hz Type of Cooling: - Forced Air — Ambient Temp: - 40 Deg Duty Class: - Class I
❖ **Boost Converter Specifications** I/P DC Voltage: - 200 Volt — O/P DC Voltage: - 600 Volt O/P DC Current upto 10 Amps — Switching Frequency upto 20 kHz

Fundamental Frequency 50 Hz	Type of Cooling: - Forced Air
Ambient Temp: - 40 Deg	Duty Class: - Class I

❖ **Solar Panel:**

The panel will be provided with suitable mounting arrangement along with 30m of cabling. The power rating of the panel is 2500W.

❖ **WAVECT - FPGA Based Controller Details:**

It is a Xilinx FPGA Zynq™-7000 SoC XC7Z020-CLG484-1with Dual ARM® Cortex™-A9 MPCore™ Which have capability Up to 667 MHz operation along with NEON™ Processing / FPU Engines.

Memory allocation in the board is given by 512 MB DDR3 and 256 Mb Quad-SPI Flash with Full size

Isolated Voltage (8) and current (8) sensors for feedback

Dual, 200 KSPS-1MSPS 16 bit 4x2 channel Simultaneous sampling for ADC

15 V, 36 PWM Out

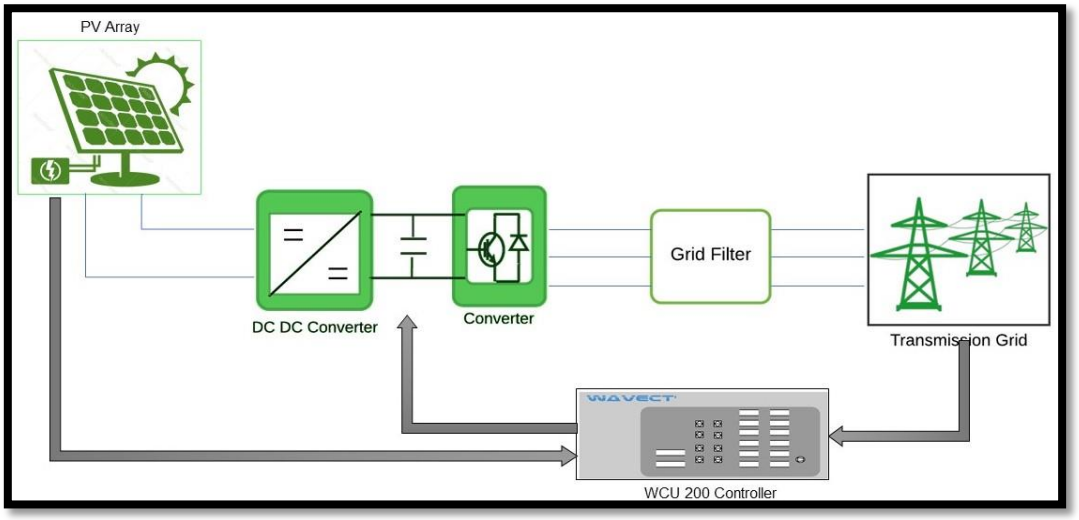

Fig- Solar Energy Module with Grid Synchronisation

EXPERIMENTS LIST

DFIG

UG (DFIG based Wind Energy Emulator Module with Grid Synchronization)

- Familiarization of wind emulator.
  - DC as wind turbine (Prime mover of shaft).
  - Power conversion required at GSC.
  - Different control and conversion methods.
  - Possible fault occurrence.

- Emulate the wind characteristics using the DC machine.
    - And obtain power for different speed, plot the data.
    - Plot P vs. Velocity Characteristics of emulator.
- Obtain the efficiency plot of emulator and compare it with real system.
- Study of MPPT system.
    - Run and test MPPT algorithm.
    - Compare the Results with and without MPPT
- Control of output power.
    - Frequency maintaining, with the help of DC machine.
    - Voltage maintaining with the help of DFIG.
- Analysis and characterization of wind stand alone system.

PG (DFIG based Wind Energy Emulator Module with Grid Synchronization)

- Introduction to graphical programming and control algorithm development.
- Create simple MPPT algorithm and run machine.
- Frequency maintaining, with the help of controller.
- Test of AC-AC converter control at generation end.
- Test inverter for different operating condition such as load change (AC and DC), wind.
- Analysis and characterization of grid connected system
- Change the system into a micro grid.
    - Control algorithm development for micro grid.
    - Converter working in synchronization mode.
- Control of converter for DFIG at both rotor end stator end (depending on from where the power is fed).
- Control of power output.
    - Obtain required Frequency, Voltage, Phase Sequence using wind emulator and DFIG.

RESEARCH OPTIONS (DFIG based Wind Energy Emulator Module with Grid Synchronization)

- Emulation of modified or totally new developed wind turbine under different loading conditions, wind speed etc.
- Testing and development of better power electronics and control for Wind Energy Generation system.
- Analysis and characterization of wind energy systems.
- Analysis of Micro-grid and smart grid integration with wind energy systems.
- Power quality analysis.
- Control techniques for regulated AC power from variable frequency AC power.

Solar PV

UG (Solar Panel Emulator Module)

- To emulate and see the I-V and P-V characteristics of PV module with varying radiation and temperature level
- Obtain the result of PV system under various conditions.
    - Different radiation, temperature, partial shade, full shade, impact angle.
    - Test for a real time environment conditions and compare the result of emulator with real.
- Run MPPT and compare the result.

PG (Solar Panel Emulator Module)

- Create MPPT for the emulator system.
- Load system under various conditions and check the output.
    - Temperature and irradiance.

RESEARCH OPTIONS (Solar Panel Emulator Module)

- MPPT algorithm testing
- Inverter control testing for different operating conditions
- Performance Analysis and Comparison of Modeled Photovoltaic Panel with PV Emulator
- Testing of charge Controller
- Micro-grid and smart grid control testing
- Performance analysis of various PV panels in different geographic locations and at different seasons/time

UG (Solar Energy Module with Grid Synchronization)

- To illustrate the I-V and P-V characteristics of PV module with varying radiation and temperature level
- To show the effect of variation in tilt angle on PV module power.
- To demonstrate the effect of shading on module output power.
- To demonstrate the working of diode as Bypass diode and blocking diode.
- Workout power flow calculations of standalone PV system of DC load.
- Workout power flow calculations of standalone PV system of AC load.
- Workout power flow calculations of standalone PV system of DC and AC load
- Run the full system and
    - Draw the charging and discharging characteristics of battery.
- Find the MPP manually by varying the resistive load across the PV panel.
- Find the MPP by varying the duty cycle of DC-DC converter.

PG (Solar Energy Module with Grid Synchronization)

- Workout power flow calculations of standalone PV system of DC load with battery.
- Workout power flow calculations of standalone PV system of AC load with battery.
- Workout power flow calculations of standalone PV system of DC and AC load with battery.
- Observe the Vm, Im, Pm and duty cycle at which MPP occurs, with MPP algorithm.
- Observe the waveforms of output voltage of inverter manually with 120 degree and 180-degree conduction mode
- Observation of Current Waveform for Linear & Nonlinear Loads and Calculations.
- Impact of Transmission Line Inductance on Voltage Quality at PCC.
- Power factor improvement using capacitor bank and its impact on power quality at PCC.
- Grid Synchronization of Solar PV Inverter and it Performance Analysis
- Evaluation of Active, Reactive & Apparent power Flow between Grid-Tied Inverter, Grid & Load and Net Metering concept.
- Demonstration of Anti-Islanding protection of Grid-Tied Inverter for Sudden Grid Failure and running the system using virtual grid

RESEARCH OPTIONS (Solar Energy Module with Grid Synchronization)

- Synchronization process for single phase solar Grid tied PV system
- Synchronization process for single phase solar Grid tied PV system
- Filter design for multilevel inverter based solar energy module
- Development of Micro-grid and smart grid control
- Study of power quality & impacts while using capacitor for power factor improvement
- Use of Solar inverter as STATCOM.
- Testing of charge Controller

OUTCOME

- Not just the theory what learned now students will also know the efforts put in the renewable energy to make it into the format that we use today.
- Every student will have idea about all the system in future if combined power generation of two renewable is required it won't lack anything.
- One can master in any of the renewable energy extraction, besides he knows other also.
- Engineers are already gone through many fault creation so decision on a necessary action will easy.
- Changing weather conditions resulting into output will be taken care with advance system.
- Student won't be experiencing or lacking any potential but they do need training and polishing.
- One can easily switch between control systems.

- Testing and analysis will be comfortable in the field.
- What, which, why, how answers to this question regarding the energy system they can figure out with ease.

CONSULTANCY

- Simulate and test the reaction time of plant with novel topology or idea before bringing it into play with real system.
- Perform a faulty condition and suggest solution for it.
- Test a new control method with the system and give suggestion for modification.
- Simulate and test likely overrated condition then observe and study to give result.
- Combined possibility to two system, challenges and changes to current system.
- Reaction time of the system with blackout and brownout.
- Safety failure recreation and testing and come out with cause and possible solution.

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Centre of Excellence in Renewable Energy developed through TEQIP-III is also listed on AKTU website, whose link is as follows:

https://aktu.ac.in/centre%20of%20Excellence.html#collapseeighteen