Defence Seminar

Seminar Title	: Development of Efficient MPPT Techniques for a Small-Scale Standalone PMSG based Wind Energy Conversion System with Energy Storage Integration
Speaker	: Mendi Balaji (Rollno : 518ee1015)
Supervisor	: Prof. Monalisa Pattnaik
Venue	: Electrical Engineering Seminar Hall-EE401 (Online)
Date and Time	: 17 Oct 2024 (11:00 AM)

Abstract : In recent years, the research and industrial communities mainly focused on renewable energy systems to combat environmental problems and also to meet the growing demand for electrical energy. Among various kinds of renewable energy sources, wind energy is gaining more support owing to its low area requirements, policy fostering, maturity of wind turbine system techniques, and zero carbon emissions during operation. Small-scale variable-speed wind energy conversion systems (VSWECS) are increasingly recognized as viable alternatives for remote areas and residential applications where large wind turbines are impractical. This system employs a permanent magnet synchronous generator (PMSG) as a variable-speed wind generator due to its advantages such as high torque density, gear-less operation, and lack of external excitation requirement. However, the small-scale PMSG-based VSWECS face challenges in extracting maximum power during varying wind speed and load conditions. Simultaneously achieving a constant output voltage along with improved reliability is also another key aspect to address.

This research work aims to develop a 2 kW standalone small-scale PMSG-based VSWECS with battery backup to meet the power demand. This dissertation proposes novel adaptive step size (ASS) and drift-free ASS (DF-ASS) maximum power point tracking (MPPT) methods for the system. The ASS and DF-ASS methods capture more power, reduce the steady-state power oscillation around MPP, and improve the tracking speed. Also, the proposed DFASS control scheme avoids the drift phenomenon during wind speed increase condition. The comparative experimental results of the proposed ASS and DF-ASS methods with respect to the fixed step size MPPT schemes show better dynamic and steady-state performance. However, the implementation of these speed sensorless MPPT algorithms (ASS and DF-ASS) needs two sensors (voltage and current) to determine the power that enhances the cost, and complexity with more power loss in the sensor circuit. Therefore to resolve the aforementioned limitations, the idea of a single sensor-based MPPT method is also analysed and proposed in this dissertation. This single load current sensor-based adaptive step size (LCAS) MPPT method utilizes only the load current information to track the maximum power. Extensive experimental work is carried out for the LCAS MPPT method that confirms better tracking efficiency, and faster tracking speed, along with the improved steady-state as well as transient performance. Further, in this dissertation the load is backed up by a battery source capable of absorbing or supplying in the event of excess and deficit wind power generation, respectively. The battery charging and discharging are controlled by a bidirectional DC-DC converter through a dual-loop PI (proportional and integral) controller (voltage mode control (VMC) and average current mode control (ACMC) loops). All the developed schemes are experimentally verified using an OPAL-RT real-time digital controller. The obtained results justify that the proposed scheme is capable of meeting the load requirements continuously despite the variations in wind speed and load, making the power generation unit self-sustainable and robust.