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WAVECT

RAPID CONTROL PROTOTYPING PLATFORM

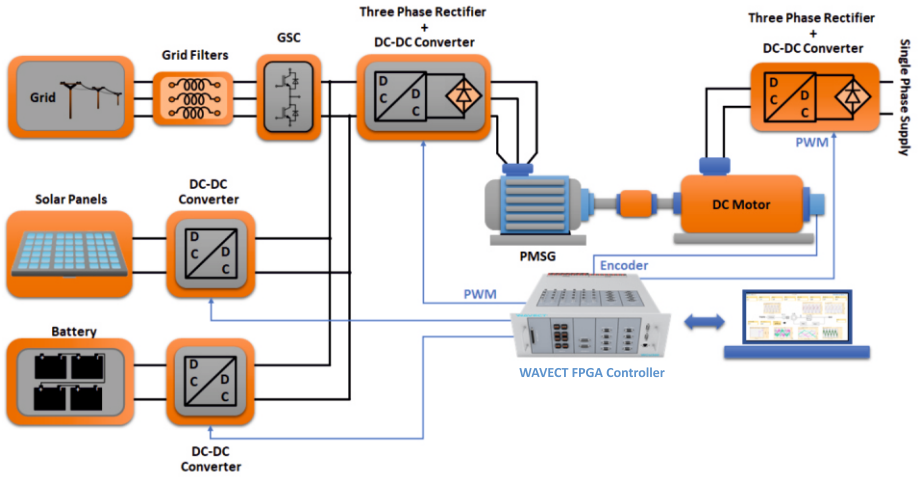
One Controller

Many Applications

Micro Grid

Hardware

- WAVECT FPGA Controller
- Rectifier + IGBT based Power Converter for GSC and DC-DC converters
- PMSG Wind Emulator Setup
- Solar PV Panel / Emulator
- Lead Acid Battery
- Inductors Filters and Other Accessories



Key Functionalities

Microgrid setup is fully user programmable. To quick start the user control design process, system is delivered with a full fleshed reference design. This reference design shows the complete operation of the setup. Its control design key functions are as follows.

- Operation of Grid Side converter
- Integration of Power source on to live Grid
- Grid PLL synchronization
- Modeling of Grid Side Filters
- Study and Modeling of MPPT algorithms for Renewable energy setup
- Auto-isolation of converters from the power under different faulty conditions.
- Provision for developing user defined control algorithms in Matlab-System Generator/HDL Coder environment.

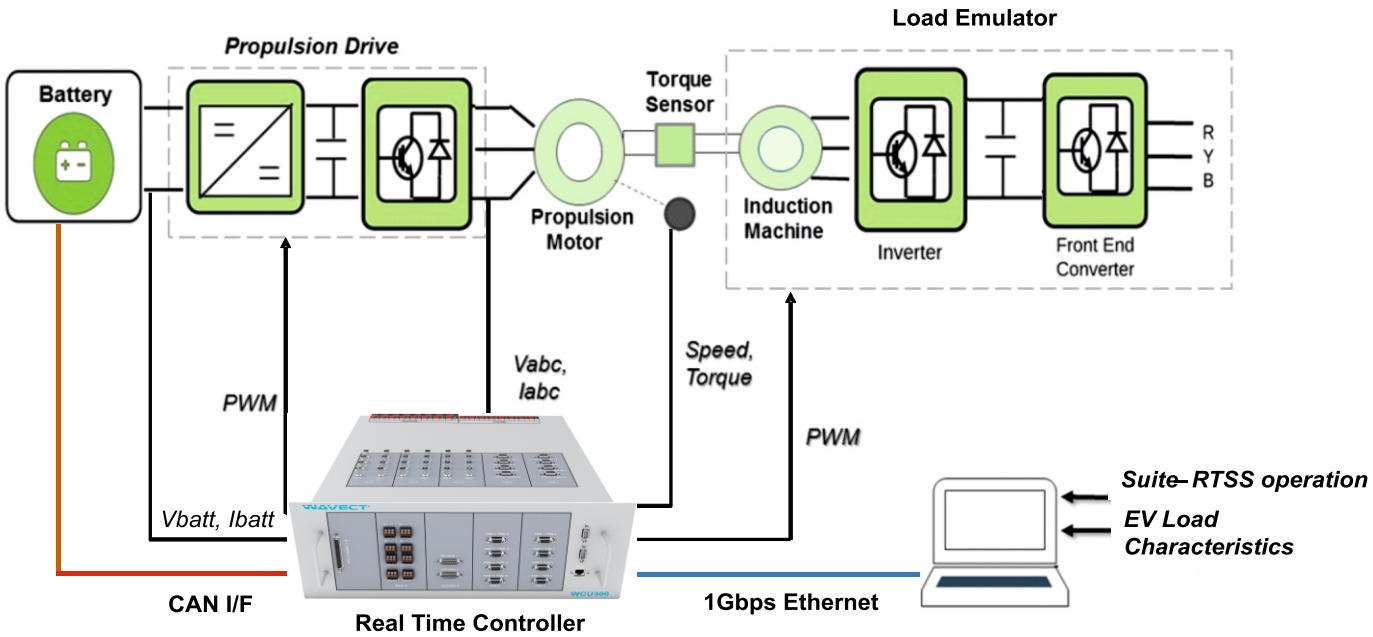
System Potential Scope

The Proposed Configuration is quite open scalable and modular , therefore there are multi-dimensional provisions to deploy the entire configuration or the individual components.

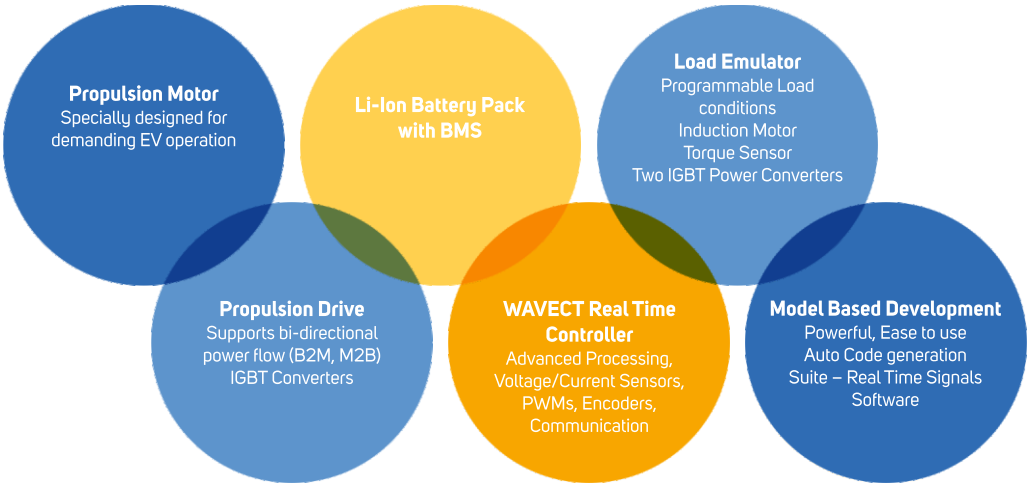
Potential list of Experiments & Research scope

- Reactive Power control on to the Live Grid and for local reactive power compensation
- THD measurement and Analysis
- Load demand management
- Islanded operation Schemes and Islanding Detection
- Distributed energy source management
- Microgrid protection and control
- Microgrid Architecture Modeling for Control operations

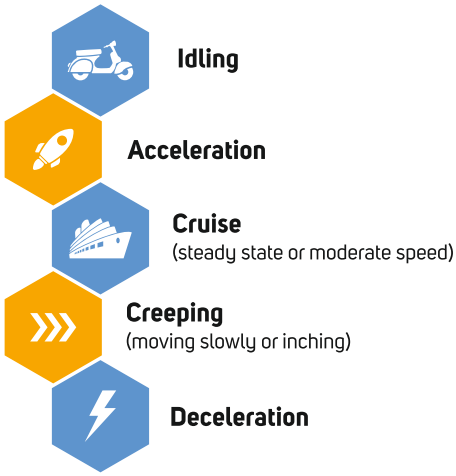
EV-Emulator Research Bed



EV Emulator – Major Components

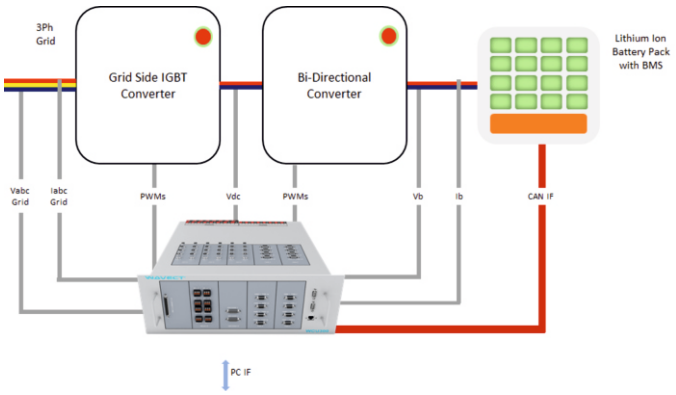


EV – Vehicle Modes



EV – Load Emulator Features

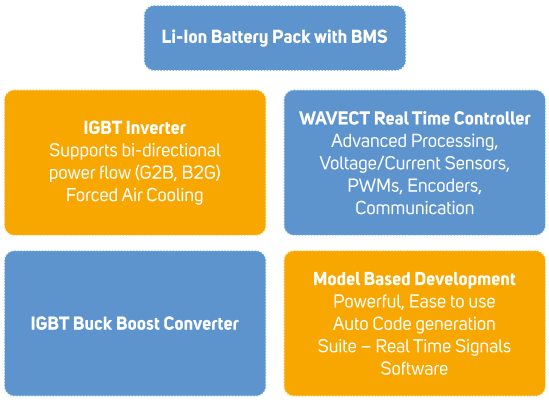
EV Battery Charging System



EV Battery Charging System – Key Features

- Dedicated BMS for tracking battery SOC levels etc.
- Dedicated CAN bus for communication of controller to BMS
- User Programmable
- Open hardware charger circuit configuration
- Real Time measurement or terminal voltage for control application purpose
- Real time monitoring and updating of battery conditions
- Support local load on grid or motor setup for drive testing application
- Reference model for basic operation and control

EV Battery Charging System– Major Components

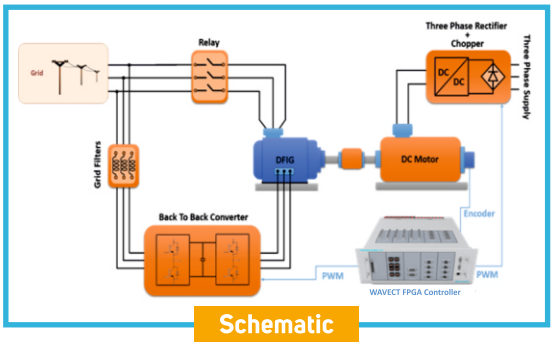


Renewables

DFIG Based Wind Energy System

Hardware

- WAVECT FPGA Controller
- Doubly Fed Induction Generator
- DC Motor as Wind Emulator
- Encoder
- IGBT based Power Converter for Grid side and rotor side converters, DC- Dc converter for DC Motor Drive and rectifier
- Inductors Filters and Other Accessories



Schematic

Real Plant

Key Functionalities

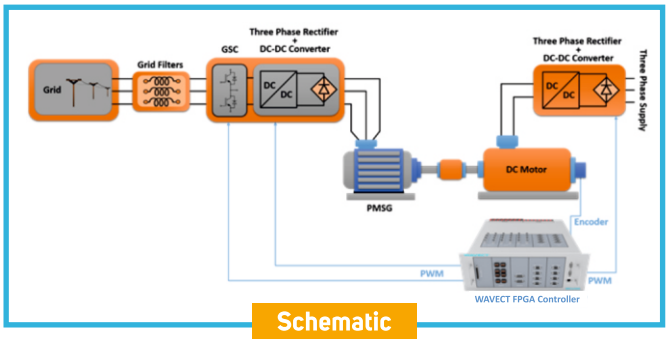
DFIG Wind Energy setup is fully user programmable. To quick start the user control design process, system is delivered with a full fleshed reference design. This reference design shows the complete operation of the setup. Its control design key functions are as follows.

- Wind Turbine Emulation
- Dynamic Parameters: wind velocity and pitch angle beta
- MPPT Algorithm for Wind
- Independent Active Power(P) & Reactive Power (Q) control for Grid Side Converter(GSC)
- Rotor Side Converter(RSC) Control for sub- and super-synchronous mode operation
- Synchronization of Stator and Grid Voltages using PLL
- Auto-isolation of emulator, generator and converters under faulty conditions.

PMSG Based Wind Energy System

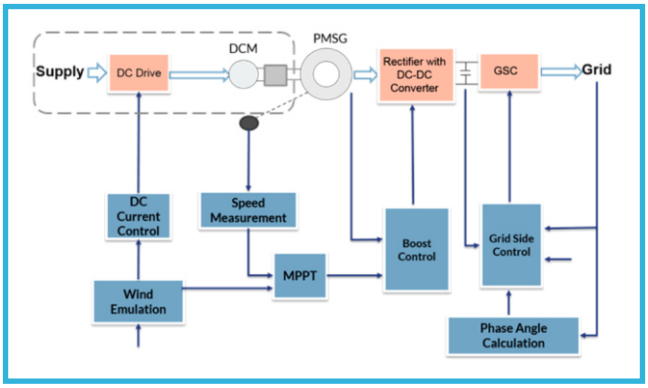
Hardware

- WAVECT FPGA Controller
- Permanent Magnet Synchronous Generator
- DC Motor as Wind Emulator
- Encoder
- Rectifier + IGBT based Power Converters for Grid side Converter, Boost converter and DC- Dc converter for DC Motor Drive
- Inductors Filters and Other Accessories



Schematic

Real Plant



Control Design

Key Functionalities

PMSG Wind Energy setup is fully user programmable. To quick start the user control design process, system is delivered with a full fleshed reference design. This reference design shows the complete operation of the setup. Its control design key functions are as follows.

- Wind Turbine Emulation
- Dynamic Parameters: wind velocity and pitch angle beta
- MPPT Algorithm for Wind
- Independent Active Power(P) & Reactive Power (Q) control for Grid Side Converter(GSC)
- Auto-isolation of emulator, generator and converters under faulty conditions.

Solar PV Energy System

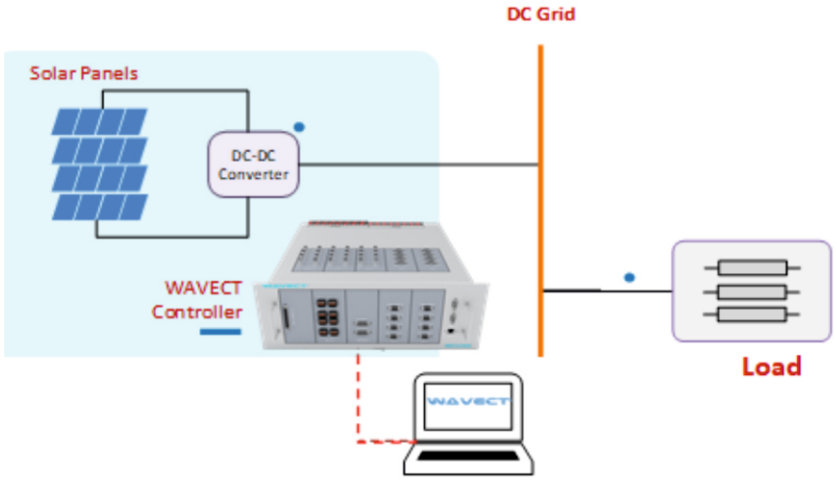
Introduction

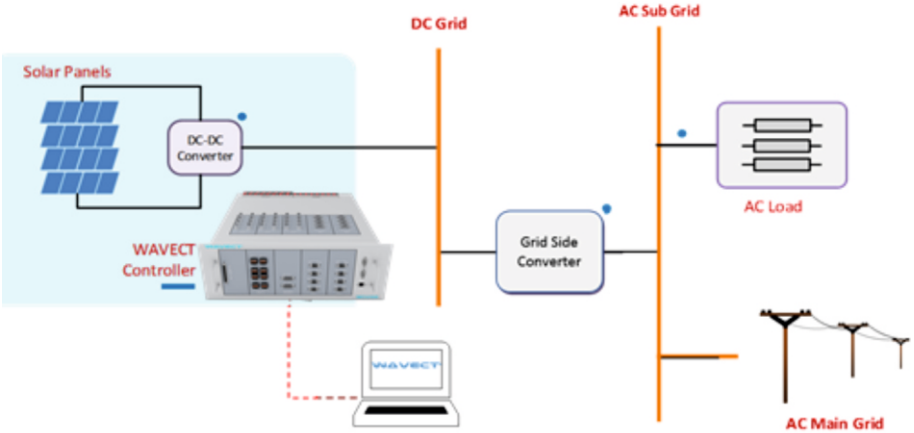
The global energy consumption is rising and an increasing attention is being paid to alternative methods of electricity generation. The very low environmental impact of the renewable energies makes them a very attractive solution for a growing demand. In this trend towards the diversification of the energy market, solar energy is a promising sustainable energy source.

Solar PV systems are generally classified into Grid-Connected, Stand alone and Hybrid Systems.

Stand-Alone PV Systems

These kind of systems are not connected to utility grid, they are self contained and are generally used in remote or rural areas



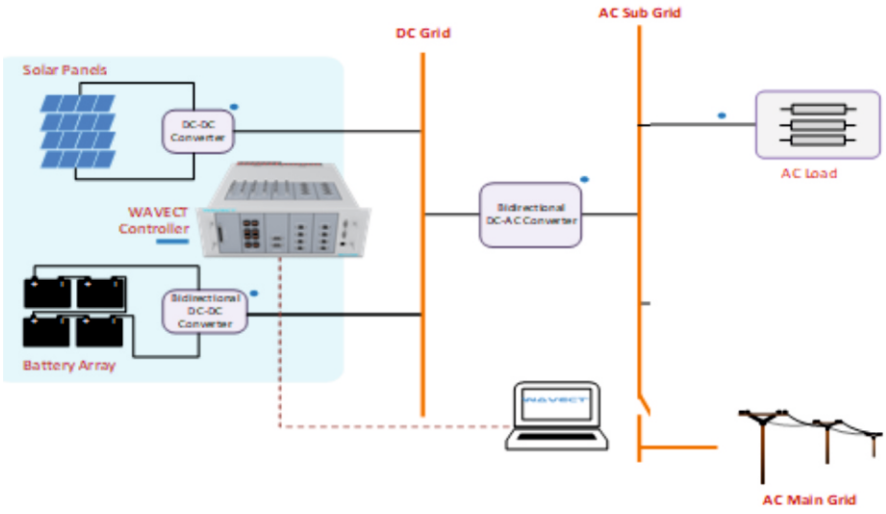


Grid Connected PV System

These type of systems are directly connected to grid via DC-AC Inverter. They are less expensive and no storage is required. In case of excess solar energy, power can be fed to grid directly and during poor weather power is supplied from AC mains and the converters can used to meet reactive power demand of the grid.

Hybrid PV systems

Hybrid system is the combination of above two systems, it can work as a grid connected system or as a standalone system with the help of batteries.

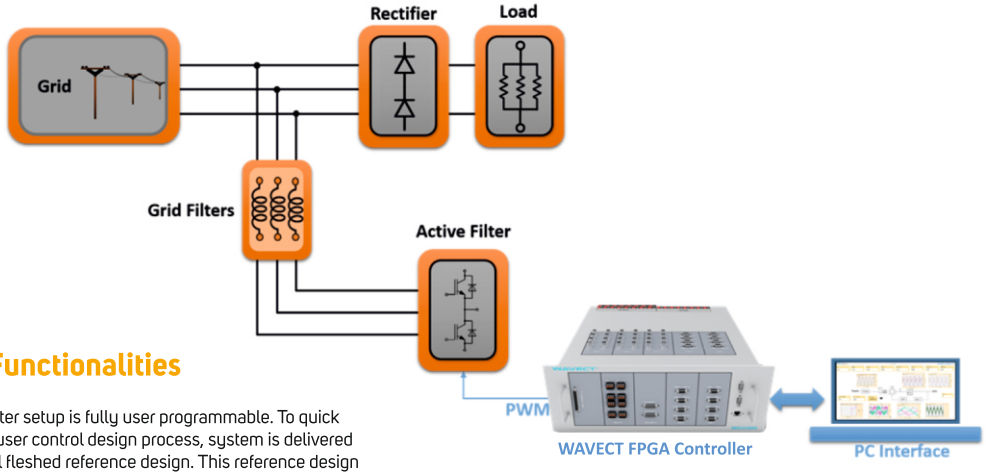


Power Quality

Active Filter

Hardware

- WAVECT FPGA Controller
- Rectifier + IGBT based Power Converters for Active Filter
- Rectifier
- DC Load
- Inductors Filters and Other Accessories



Key Functionalities

Active Filter setup is fully user programmable. To quick start the user control design process, system is delivered with a full fleshed reference design. This reference design shows the complete operation of the setup. Its control design key functions are as follows.

- Harmonics Compensation
- Reactive Power Compensation
- Auto-isolation of converters from the power under different faulty conditions.
- Provision for developing user defined control algorithms in Matlab-System Generator/HDL Coder environment.

System Potential Scope

The Proposed Configuration is quite open scalable and modular , therefore there are multi-dimensional provisions to deploy the entire configuration or the individual components.

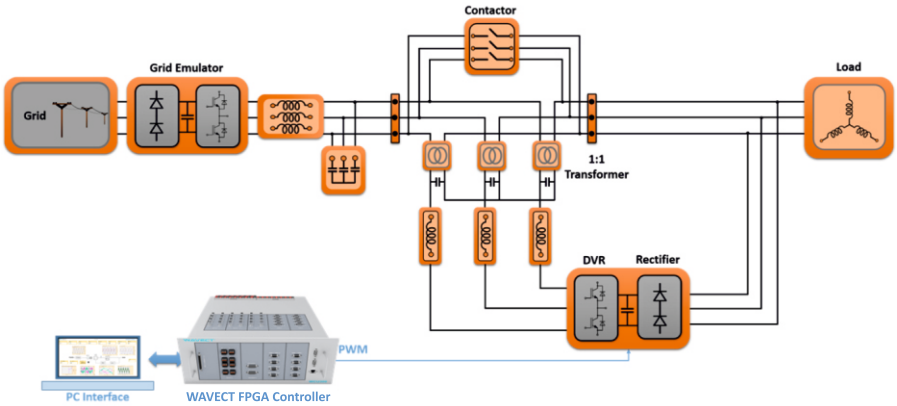
Potential list of Experiments & Research scope

- Possible fault occurrences.
- Statcom control development.
- Unified Power Quality Conditioner control development
- Controllable DC load development.
- Development of different inverter control techniques.

DVR

Hardware

- WAVECT FPGA Controller
- Rectifier + IGBT based Power Converters for DVR and Inverter
- AC Load
- Transformer
- Inductors Filters and Other Accessories



Key Functionalities

DVR setup is fully user programmable. To quick start the user control design process, system is delivered with a full fleshed reference design. This reference design shows the complete operation of the setup. Its control design key functions are as follows.

- Sag and Swell Compensation
- Provision to emulate different types of faults to DVR
- Auto-isolation of converters from the power under different faulty conditions.
- Provision for developing user defined control algorithms in Matlab-System Generator/HDL Coder environment.

System Potential Scope

The Proposed Configuration is quite open scalable and modular , therefore there are multi-dimensional provisions to deploy the entire configuration or the individual components.

Potential list of Experiments & Research scope

- Possible fault occurrences.
- DVR control development.
- Unified Power Quality Conditioner control development.
- Different types of fault emulation development.
- Development of different inverter control techniques.

Grid Emulator

Key Functionalities

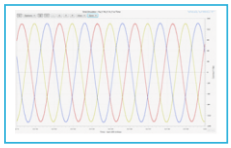
Grid Emulator setup is fully user programmable. To quick start the user control design process, system is delivered with a full fleshed reference design. This reference design shows the complete operation of the setup. Its control design key functions are as follows.

It can generate different types of grids:

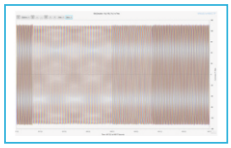
- Three phase power grid from 0 to 440Vac
- Frequency 10 - 60 Hz
- Single phase and two phases voltages for specified duration

Faults that can be generated:

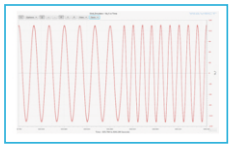
- Voltage Sag between 60 % – 90 % for specified duration
- Voltage Swell between 110 % – 120 % for specified duration
- Under Voltage 60 % – 90 %
- Over Voltage 110 % – 120 %
- Unbalanced Voltages for specified duration



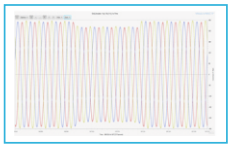
Three phase 440 V AC



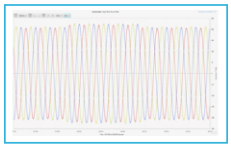
Three phase frequency change



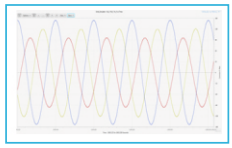
Single phase frequency change



80 % Voltage Sag



110 % Voltage Swell



Unbalanced Voltages

Hardware

- WAVECT FPGA Controller
- Rectifier + IGBT based Power Converters for Front End Converter and Inverter
- Inductors Filters and Other Accessories

System Potential Scope

The Proposed Configuration is quite open scalable and modular , therefore there are multi-dimensional provisions to deploy the entire configuration or the individual components.

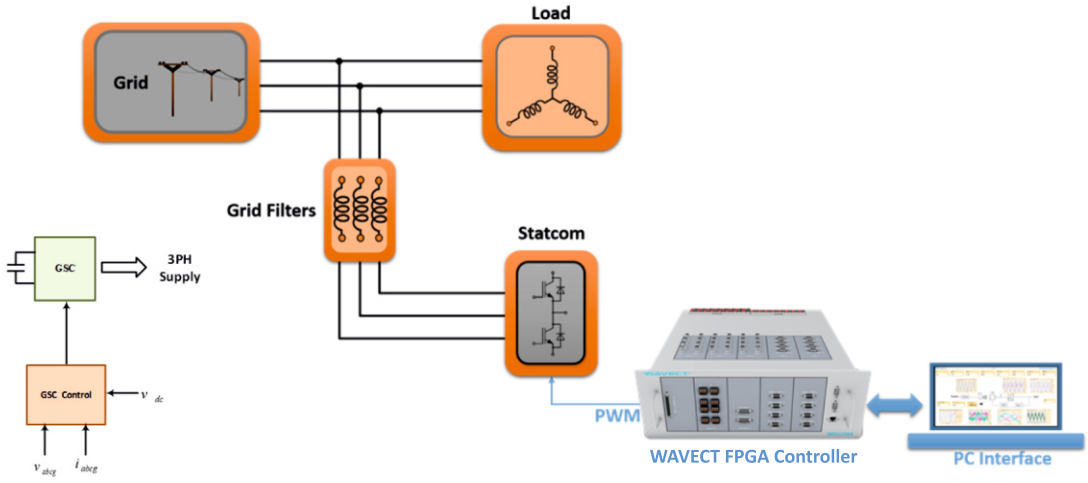
Potential list of Experiments & Research scope

- Possible fault occurrences.
- Effect of possible faults at different systems.
- Effect of different faults at different loads.
- Emulation of new faults such as flicker , harmonics etc.
- Inverter control testing for different operating conditions.
- Development of different inverter control techniques.

Statcom

Hardware

- WAVECT FPGA Controller
- Rectifier + IGBT based Power Converters for Active Filter
- AC Load
- Inductors Filters and Other Accessories



Control Model

Key Functionalities

Statcom is fully user programmable. To quick start the user control design process, system is delivered with a full fleshed reference design. This reference design shows the complete operation of the setup. Its control design key functions are as follows.

- Reactive Power Compensation
- Auto-isolation of converters from the power under different faulty conditions.
- Provision for developing user defined control algorithms in Matlab-System Generator/HDL Coder environment.

System Potential Scope

The Proposed Configuration is quite open scalable and modular , therefore there are multi-dimensional provisions to deploy the entire configuration or the individual components.

Potential list of Experiments & Research scope

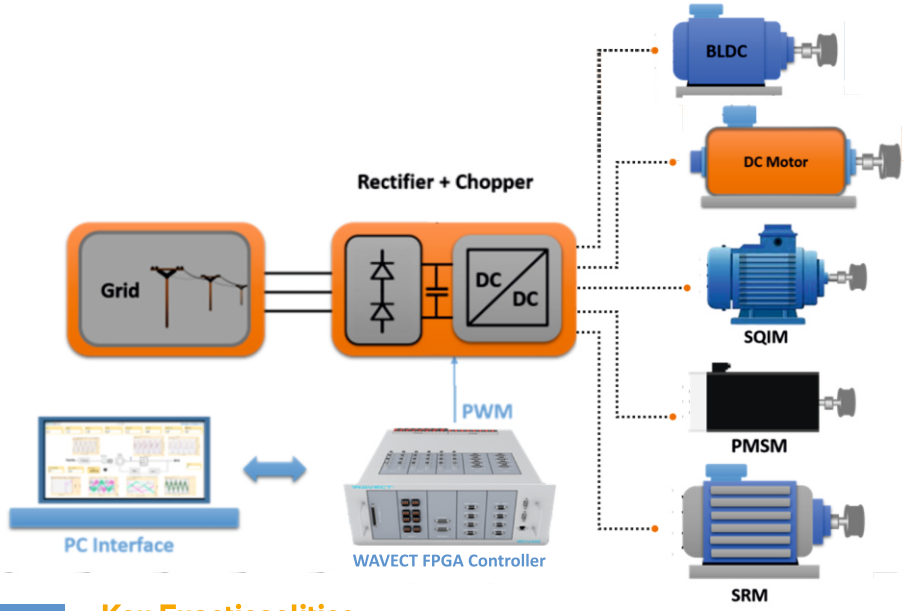
- Possible fault occurrences.
- Active Filter control development.
- Unified Power Quality Conditioner control development
- Controllable AC load development.
- Development of different inverter control techniques.

Drives

BLDC Drive

Hardware

- WAVECT FPGA Controller
- Rectifier + IGBT based Power Converter for Inverter
- BLDC Motor With Mechanical Loading



System Potential Scope

The Proposed Configuration is quite open scalable and modular , therefore there are multi-dimensional provisions to deploy the entire configuration or the individual components.

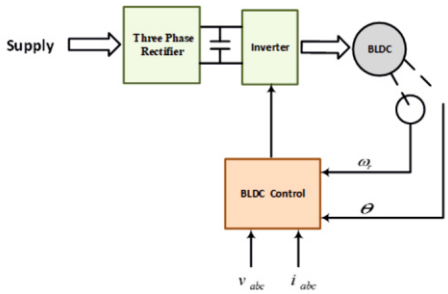
Potential list of Experiments & Research scope

- Commutation Table based Speed Control of BLDC
- Closed loop Speed Control of BLDC
- Current Controlled Operation of BLDC
- Sensor less Control of BLDC motor
- BLDC Drives with Renewables Integration
- Direct Torque control of BLDC
- Back Emf waveform estimation
- Regenerative braking
- Four quadrant operation of BLDC Drive
- Torque ripple Minimizations

Key Functionalities

BLDC Drive setup is fully user programmable. To quick start the user control design process, system is delivered with a full fleshed reference design. This reference design shows the complete operation of the setup. Its control design key functions are as follows.

- Voltage Mode Control.
- Sensor less control.
- Auto-isolation of converters from the power under different faulty conditions.
- Provision for developing user defined control algorithms in Matlab-System Generator/HDL Coder environment.



DC Drive

Hardware

- WAVECT FPGA Controller
- Rectifier + IGBT based Power Converter for DC/DC converter
- Separately Excited DC Motor with Mechanical Loading

Key Functionalities

DCM Drive setup is fully user programmable. To quick start the user control design process, system is delivered with a full fleshed reference design. This reference design shows the complete operation of the setup. Its control design key functions are as follows.

- Open loop Control.
- Closed loop Control.
- Auto-isolation of converters from the power under different faulty conditions.
- Provision for developing user defined control algorithms in Matlab-System Generator/HDL Coder environment.

System Potential Scope

The Proposed Configuration is quite open scalable and modular , therefore there are multi-dimensional provisions to deploy the entire configuration or the individual components.

Potential list of Experiments & Research scope

- Open Loop control of DC Motor
- Closed Loop Armature Voltage control of DC Motor
- Designing Buck converters schemes for DC Motor Drive
- Field Voltage control for Speed control
- Armature current control schemes for DC Motor
- Designing of Filter Inductors for Buck converter

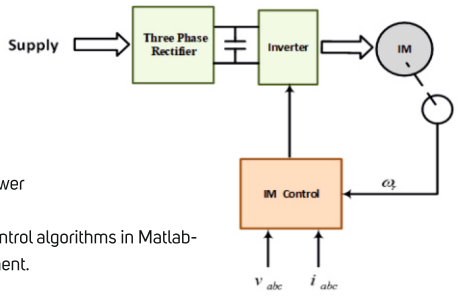
Induction Motor Drive

Hardware

- WAVECT FPGA Controller
- Rectifier + IGBT based Power Converter for Inverter
- Squirrel Cage Induction Motor

Key Functionalities

IM Drive setup is fully user programmable. To quick start the user control design process, system is delivered with a full fleshed reference design. This reference design shows the complete operation of the setup. Its control design key functions are as follows.



- V/F mode of operation.
- Indirect vector control.
- Auto-isolation of converters from the power under different faulty conditions.
- Provision for developing user defined control algorithms in Matlab-System Generator/HDL Coder environment.

System Potential Scope

The Proposed Configuration is quite open scalable and modular, therefore there are multi-dimensional provisions to deploy the entire configuration or the individual components.

Potential list of Experiments & Research scope

- Open Loop Scalar Speed Control of IM
- V/f Closed loop Speed Control of IM
- V/f Closed loop Speed Control of IM with Space Vector Modulation
- V/f with boost Closed loop Control for IM
- Field Oriented Control of IM
- Direct Torque control of IM
- Regenerative braking
- Four quadrant operation of IM Drive
- Rotor Flux and Stator flux analysis
- Flux weakening operation

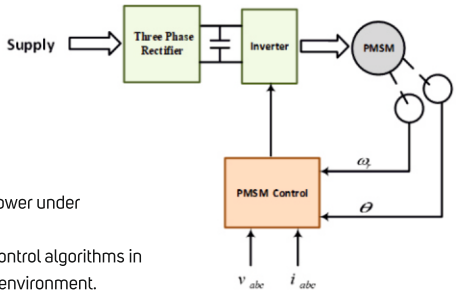
PMSM Drive

Hardware

- WAVECT FPGA Controller
- Rectifier + IGBT based Power Converter for Inverter
- PMSM with Mechanical Loading

Key Functionalities

PMSM Drive setup is fully user programmable. To quick start the user control design process, system is delivered with a full fleshed reference design. This reference design shows the complete operation of the setup. Its control design key functions are as follows.



- Open loop Control.
- Closed loop Control.
- Field Oriented Control
- Auto-isolation of converters from the power under different faulty conditions.
- Provision for developing user defined control algorithms in Matlab-System Generator/HDL Coder environment.

System Potential Scope

The Proposed Configuration is quite open scalable and modular, therefore there are multi-dimensional provisions to deploy the entire configuration or the individual components.

Potential list of Experiments & Research scope

- Commutation Table based Speed Control
- Open Loop Speed Control of PMSM
- Closed loop Speed Control of PMSM
- Field Oriented Control of PMSM
- Direct Torque control of PMSM
- Back emf waveform estimation
- Regenerative braking
- Four quadrant operation of PMSM Drive
- Flux based control and Analysis

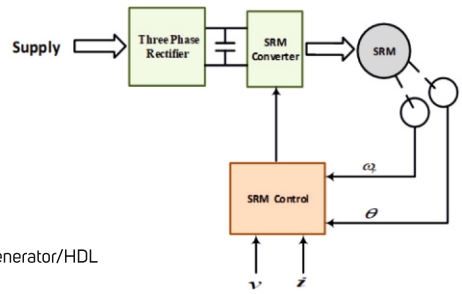
SRM Drive

Hardware

- WAVECT FPGA Controller
- Rectifier + 4 Phase IGBT based Power Converter for Inverter
- SRM Motor with Mechanical Loading

Key Functionalities

SRM Drive setup is fully user programmable. To quick start the user control design process, system is delivered with a full fleshed reference design. This reference design shows the complete operation of the setup. Its control design key functions are as follows.



- Open loop Control.
- Closed loop Control.
- Auto-isolation of converters from the power under different faulty conditions.
- Provision for developing user defined control algorithms in Matlab-System Generator/HDL Coder environment.

System Potential Scope

The Proposed Configuration is quite open scalable and modular, therefore there are multi-dimensional provisions to deploy the entire configuration or the individual components.

Potential list of Experiments & Research scope

- Switching Table based Open Loop Control of SRM
- Closed Loop Control of SRM
- Current control of SRM Drives
- Torque ripple minimization
- Noise reduction schemes
- Regenerative Braking

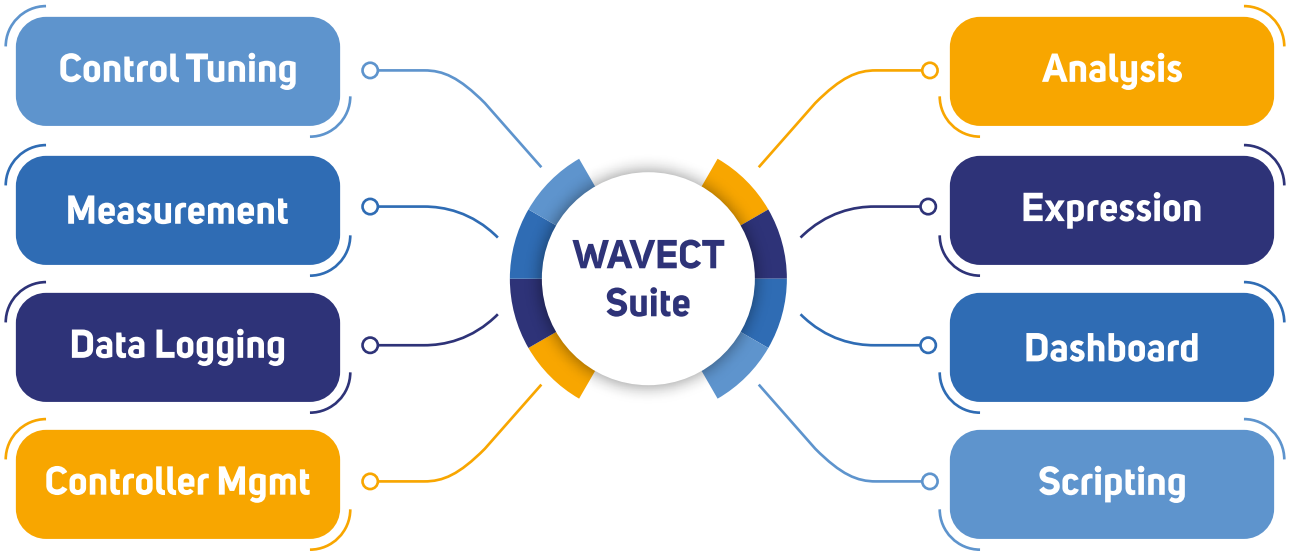
WAVECT- Rapid Control Prototyping Platform

- FPGA & Dual Core ARM processor system
- Integrated Voltage and Current sensors
- Ready to use High Switching Frequency PWMs up to 2 MHz
- Control Function latency <5µs.
- High speed Analog & Digital I/O s
- Configurable Hardware Protections
- Isolated communication ports like dual CAN, dual RS485, RS232 and Gigabit Ethernet interface for PC connectivity
- Equipped with Powerful Software suite for Data Visualization, Control, Measurement and Analysis
- Dynamic parameter modification and testing

WAVECT Specifications

Controller	• Xilinx ZYNQ SoC: Dual ARM Cortex-A9 MP Core, NEON Processing/FPU Engines, Artix FPGA • 512 MB DDR3, 256 MB Quad-SPI Flash and SD Card • Control function execution fully on FPGA fabric • Gigabit Ethernet interface
PWM Channels	• Isolated High Speed PWMs – up to 2MHz Switching Frequency with 100 steps • 15V/5V Output Voltage Level – Factory option • Up to 5ns PWM resolution
Voltage Sensor	• Channel to Channel Isolated Voltage Sensing • +/-1000V Peak Input Range • Up to 1 MSPS per channel sampling, Parallel sampling of all Channels • Delta-Sigma A/D conversion: 16-bit resolution
Current Sensor	• Closed Loop Fluxgate current sensor • Channel to Channel Isolated • Range: 25A RMS, +/-80A Intermittent measuring range • Up to 1 MSPS per channel sampling, Parallel sampling of all Channels • Delta-Sigma A/D conversion: 16-bit resolution
Analog Inputs	• Channel to Channel Isolated Inputs • +/-10V Peak Input Range • Up to 1 MSPS per channel sampling, Parallel sampling of all Channels • Delta-Sigma A/D conversion: 16-bit resolution
Analog Outputs	• +/-10V DAC Outputs, Isolated from SoC • 16-bit resolution • Up to 2 MSPS per channel sampling • Over current Protection
Encoder Interface	• Four RS422 differential inputs per channel, Isolated from SoC • +5V 0.25A power provision per channel • DB15 connector per channel
Relay Interface	• SPDT Relay, 250VAC, 5A switching current
Buzzer	• Programmable Buzzer output
Communication Ports	• Dual CAN Ports: CAN 2.0B Ports, Signal and Power Isolated, DE9 connector • Dual RS485 Ports: Full Duplex ports, Signal and Power Isolated, DE9 connector, UART • RS232 Port: UART Protocol support, Signal and Power Isolated, DE9 connector
Modelling	• Powerful modelling support • User selectable FPGA Sample time up to 10ns • Dedicated wavect Dev Library: Model check, Easy IO block configuration and Single click binary generation • Dedicated Application blockset library

WAVECT Suite



Test Framework

- User Configurable Dashboards
- Instantaneous Time plot
- FFT Panel
- Power Panel
- Energy Panel
- Power Analyzer
- Expression Panel
- Data logging

Controller Options Available

Tru-Control

- DSP + FPGA Controller
- Faster Loop time of 10µs
- High Switching Frequency up to 1MHz PWM
- Hardware Protections
- Fast test iterations & Easy Modelling

WAVECT Target

- Deploy WAVECT target model quickly
- Reduce risk and faster time to market
- Optimized, Low cost, compact board
- Customization available on demand
- Contact for more info

ENTUPLE TECHNOLOGIES

About us

- 13+ Years
- 150+ Corporate Customers
  - A&D • PSU
  - Mid-Market + SME
- 125+ Strong Team
- 12+ Offices
- 630+ Academic Customers
  - IIT • NIT
  - Top Govt and Pvt

Our Presence

Areas of Expertise

- Mechanical
- CFD
- EMAG
- Systems
- Semiconductors
- eMobility
- PCB Design
- PCB Proto
- Additive Manufacturing
- Materials
- VNA
- RF Solutions
- Cyber Security
- Internet of Things
- Power Electronics

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