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1.5 KW Hybrid PQ-DQ Axis Grid Synchronized 1/3Φ Inverter with Bi-Directional Buck-BoostConverter for Battery

Model: PEC16-HBBOC3VSI-01

An Innovative Trainer for Grid Connected 3ΦInverter Trainer with 2 types of Grid Synchronizing Techniques and 3 Types of MPPT Algorithm and Bi Directional Buck-Boost Converter for Battery Charging –Boosting to DC Bus Voltage of 350VDC

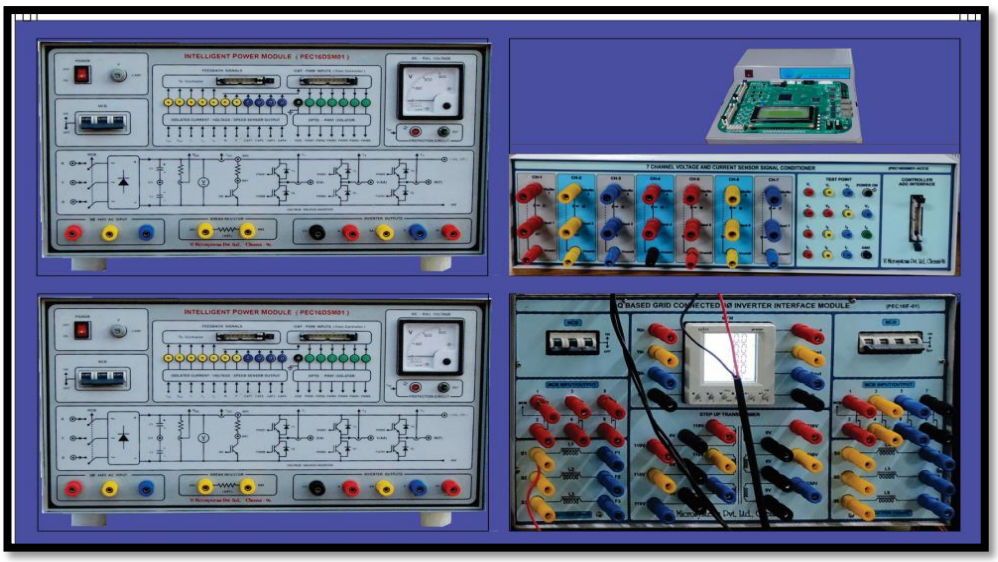
i. DQ Based abc-dq controller for Hybrid Solar, Wind Turbine & Battery System
ii. PQ Based Instantaneous real and reactive power control
iii. 3 Types of MPPT Algorithms.

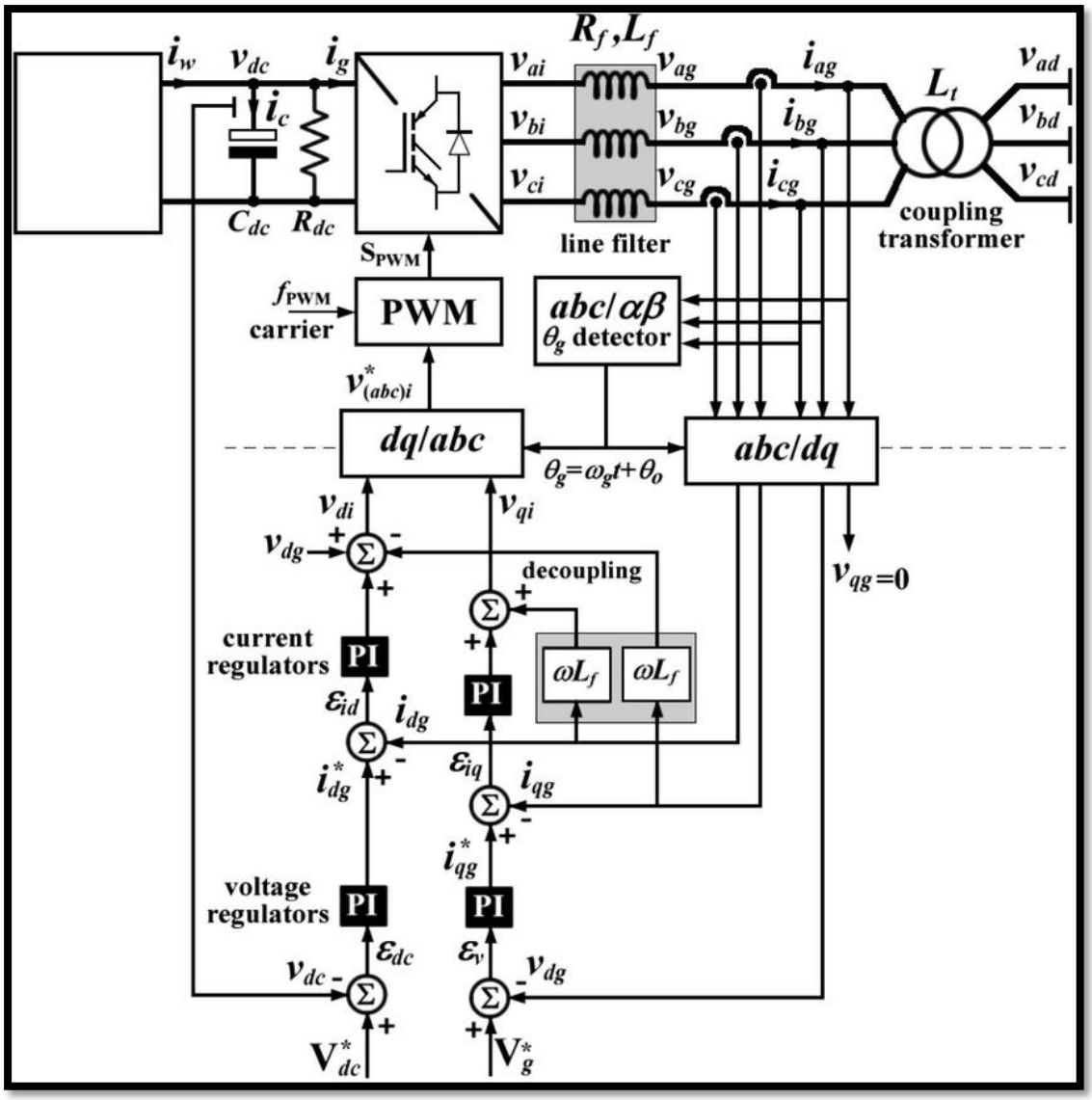
The main objective of this trainer is to achieve high-performance decoupled control of the active and reactive powers injected to the grid from Hybrid Solar & Wind energy resources

An Innovative product for the Renewable Energy Lab. It provides

i. DC-DC Boost Conversion for solar
ii. DC-DC Boost Conversion for Wind
ii. Battery Charging
iii. Grid Synchronised and Standalone DC – AC (1Φ/3Φ) Inverter based on DQ Axis BasedGrid Synchronization
iv. DUAL CORE DELFINO DSP CONTROLLER
v. Matlab – Simulink DQ algorithm implementation for OFF Grid and ON Line Grid connection
vi. Single product for both Off Grid & On Grid operations
vii. Model based design of this product using Matlab - Simulink

Three Phase Grid Connected Photovoltaic System with Active and Reactive Power Control Using "Instantaneous Reactive Power Theory"
The photovoltaic (P/V) system, with maximum power point tracking (MPPT), connected to a three phase grid is also incorporated.


INTELLIGENT POWER MODULE (PEC16DSM01)
7 CHANNEL VOLTAGE AND CURRENT SENSOR SIGNAL CONDITIONER
INTELLIGENT POWER MODULE (PEC16DSM01)
BASED GRID CONNECTED 1Ø INVERTER INTERFACE MODULE

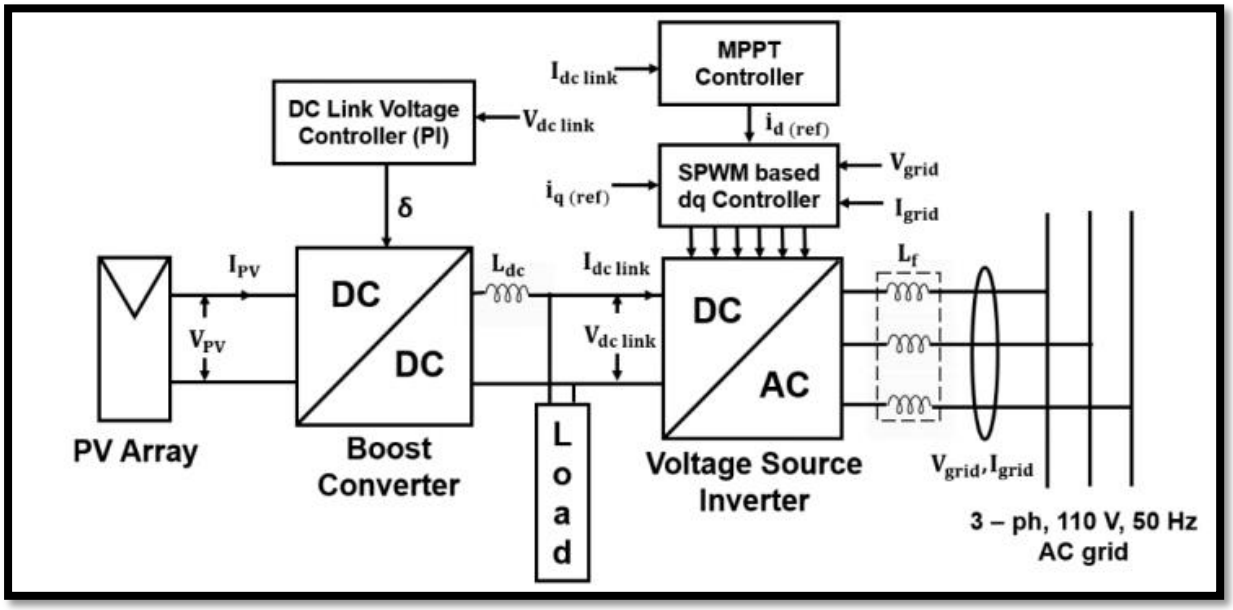

i_w
v_{dc}
i_g
i_c
C_{dc}
R_{dc}
R_f, L_f
v_{ai}
v_{bi}
v_{ci}
v_{ag}
v_{bg}
v_{cg}
line filter
i_{ag}
i_{bg}
i_{cg}
L_t
v_{ad}
v_{bd}
v_{cd}
coupling transformer
S_{PWM}
f_{PWM} carrier
PWM
$abc/\alpha\beta$ θ_g detector
$v^*_{(abc)i}$
dq/abc
abc/dq
$\theta_g=\omega_g t+\theta_o$
v_{di}
v_{qi}
v_{dg}
$v_{qg}=0$
decoupling
current regulators
PI
ωL_f
ε_{id}
i_{dg}
i^*_{dg}
ε_{iq}
i_{qg}
i^*_{qg}
voltage regulators
ε_{dc}
v_{dc}
V^*_{dc}
ε_v
V^*_g

The increasing computation capability of high-speed digital signal processors (DSP – 800MIPS TMS320F28377D) and the availability of various hardware-in-the loop (HIL- MATHLAB SIMULINK) control have facilitated the development and implementation of this sophisticated control algorithms for achieving reliable grid-integrated systems.

The gate pulses for the IGBTs used in boost converter for PV & Wind, Bidirectional DC-DC Buck –Boost Converter and VSI are generated using 800MIPS, Dual Core DSP Processor TMS320F28377D.

The hardware of the complete system is implemented with 1000W PV array and 1000W Wind Turbine feeding a three-phase 440V,50 Hz grid. Both simulation and experimental results are furnished to demonstrate the efficacy of this developed Trainer.

The following Figure shows this High Performance three-phase inverter controlled by Instantaneous real and reactive power theory (PQ theory) based PI controllers

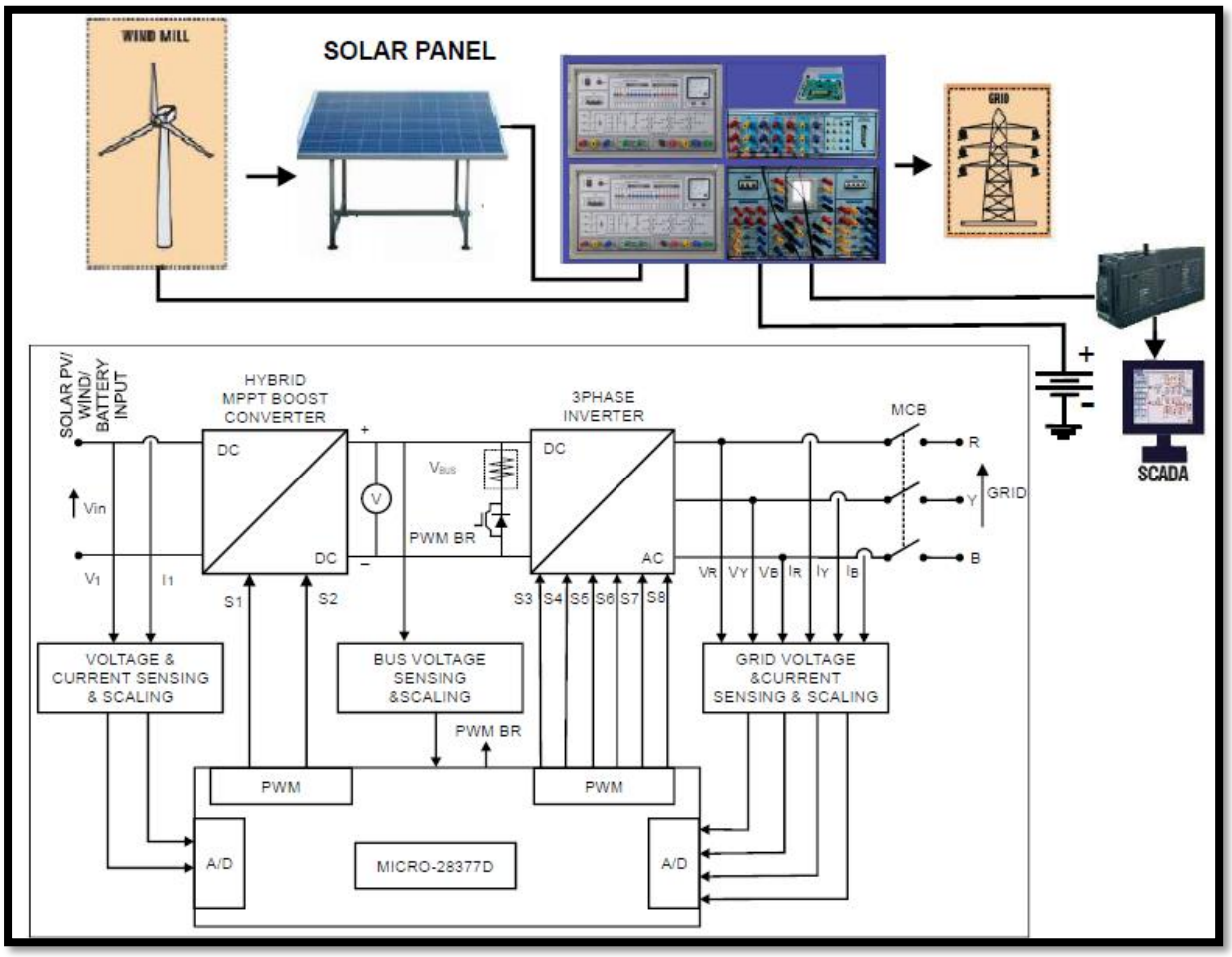


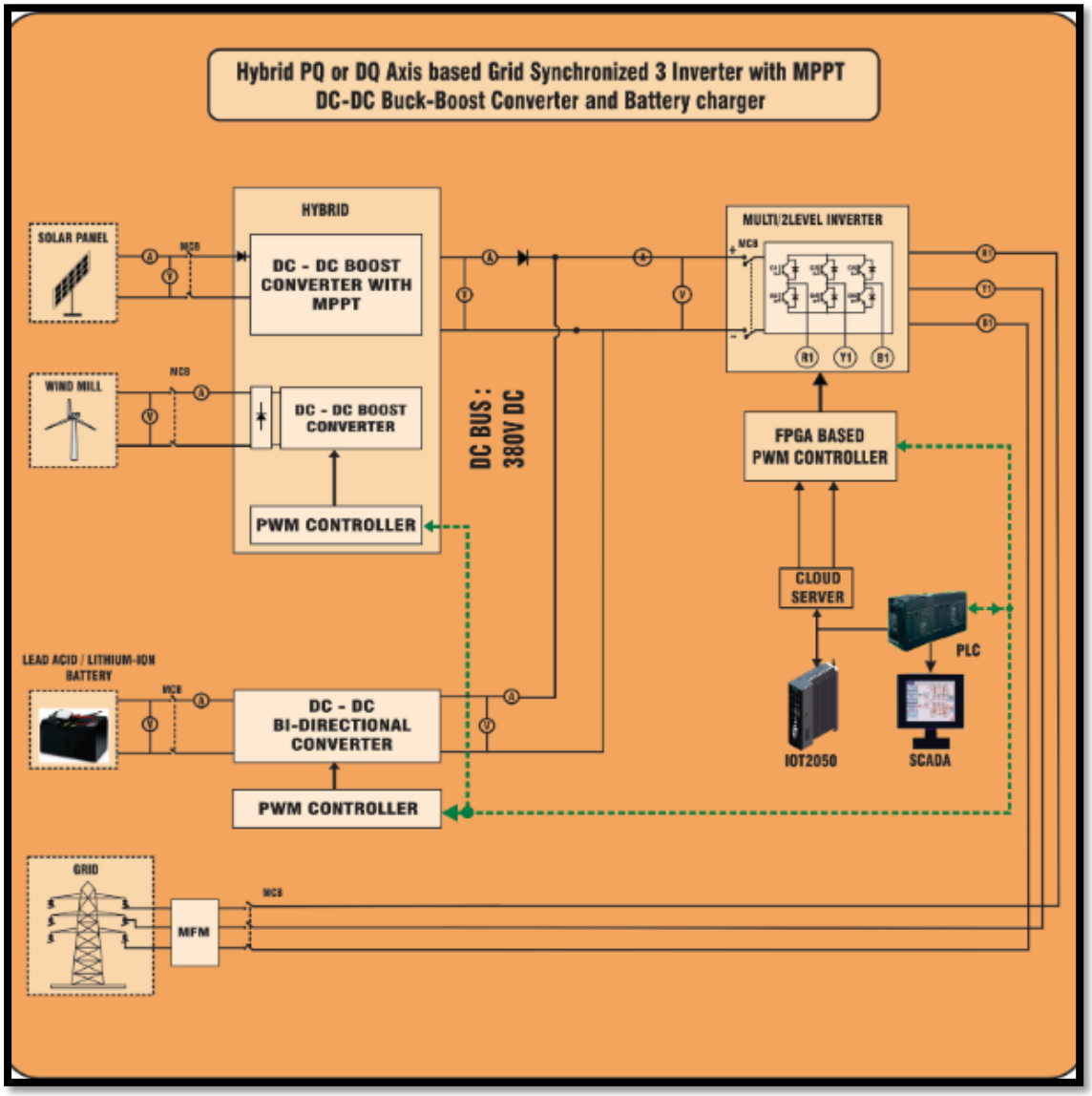
This Trainer for RENEWABLE ENERGY LAB with MATLAB SIMULINK model based Design, has been designed with the following features .

Two Front End Boost converters for Solar & Wind, one Buck-Boost Converter for Battery Charging – Boosting the battery voltage to DC Bus, DQ Axis based 3Φ Inverter provided to study theRenewablesolar&windbased MPPT and Grid connected 3Φ Solar PV Power wind turbine Generation.

Each section of the Trinerlike MPPT algorithm, DC-DC Boost Converter, DC-DC Buck- Boost conversion for battery,DQ based 1/3Φ Inverter, DSP Controller techniques can be studied using MATLAB SIMULINK Blocks.

* Three phase grid synchronized inverter for solar PV panels& Wind Turbine
* PLL based grid synchronization
* Control algorithm based on instantaneous power theory; and operation of Grid Synchronized inverter
* A TMS320F28377D based DSP Controller provided to implement DQ Axis Algorithm with Space Vector Modulation.
* AC output voltage: 415V ±10%, Three Phase, 50Hz
* AC output voltage: 230V ±10%, Single Phase, 50Hz
* Power rating: 1 kVA(max)





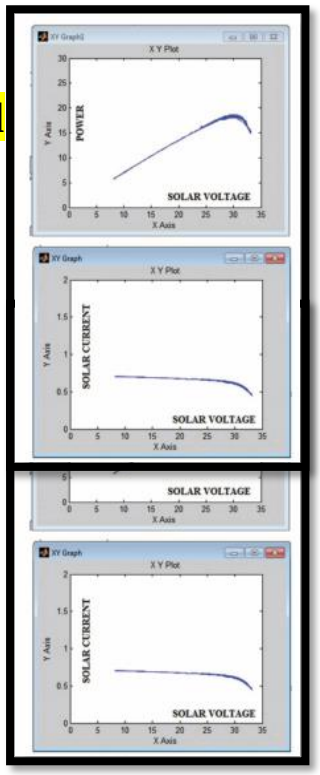
IPM - IGBT BASED POWER MODULE SECTION AS INVERTER

* Power Module is designed for Inverter Applications upto 2 KW by using the 3rd Generation Semikron IGBT& DIODE Technology
* Input : DC Upto 650VDC
  Output : 400V/10A (MAX), AC/DC on each Leg of 3 phase Bridge
* 1200V, 25A, 3 Phase IGBT Inverter Bridge
* 1200V, 10A IGBT for over voltage Breaking
* Protection :over voltage, under voltage, over current & over Temperature Protection

ADDITIONAL FEATURES

* 1200V, 25A Converter Bridge for AC-DC power conversion
* 4 Nos of Hall Effect current sensors to sense the DC Link current & 3 output Currents of the Inverter Bridge
* 1 No of Hall Effect Voltage sensor to sense DC Link voltage
* All the PWM signals are isolated using Opto Isolator
* Protection circuit for over current with LED indication
* Optically Isolated Fault signal from the IPM is given to the Embedded/DSP controllers for protection.
* Independent Power supplies for all Isolated circuits.
* 0-900V Voltmeter to Indicate the DC Link Voltage
* All current, PWMS & Feedbacks are terminated at Front panel
* FRC Connectors are provided to Interface with the Embedded/DSP controllers
* All the Input/Output Lines are terminated at Banana sockets.

2nd IPM- IGBT Power Module Provided for **Solar Boost Converter Section.**
Wind Turbine Boost Converter Section &Bi-Directional Battery Charging& Boosting Battery Voltage of 240V to 350 V DC-Bus Voltage Section with MPPT



Solar Boost Converter Section

* One LEG of 2 IGBT provided for Boosting the Solar Panel output to 350V DC Bus.
*Output power 1000W,
*Input 210-240V from Solar Panel & Output 350V DC
*Switching frequency <20kHz
*Designed for Solar Panel: 1000W
*Boost convertor operation in open loop & close loop mode
*Real time P-V and I-V curve can be updated and analyzed anytime

3 MPPT ALGORIHMS

As MPPT control is necessary to extract maximum power from the PV arrays, we have implemented 3 types of algorithm.

Perturb & Observe
Hills &Climp
incremental conductance (IncCond),

Wind Turbine Boost Converter Section

*One LEG of 2 IGBT provided for Boosting the wind Turbine output to 150V DC Bus.
*Output power 200W,
*Input 30-60V from Wind Turbine & Output 150V DC-350VDC
*Switching frequency < 20kHz
*Designed for Wind Turbine : 1000W
*Boost convertor operation in open loop & close loop mode

*Two MPPT algorithm Hill Climp And Perturb & Observe
*Real time P-V and I-V curve can be updated and analyzed anytime

The DQ algorithm is implemented using a DUAL CORE DELFINO BASED DSP Controller for standalone and Grid connected inverter operation and following algorithm Implementable

* Decoupled Active and Reactive power control
* Connection to the Grid is realized by current
* Control in DQ rotating reference frame
* Instantaneous Power control algorithm using PQ theory
* Grid connected algorithm with decoupled control of active and reactive power
* PLL based Grid synchronization

2. 1000W Solar panel

Make : Reputed approved by MNRI
No of Panels : 250W - 4Nos.
Peak Power of Module : 1000 Watts
Humidity : 0 to 100%
Type of cell : Poly crystalline silicon
Lamination Type : Vacuum Laminated Glass to ladler
Voc of each module : 38 Volts
Fixing mechanical setup

3. 1000W Wind Turbine fixed in the roof

* 3 Phase 48V Wind mill Turbine

* 1KW Wind Turbine
* Three Blades
* Nominal Voltage 48V
* Maximum Power 1000W
* Start Wind speed 5m/s
* Rated Wind Speed 13m/s
* Rated revolution 450r/m
* Security wind speed 50m/s
* Wind wheel diameter 2.4m
* Lead number : 3
* Blade material : Nylon Fibre
* Generator : Three phase Permanent magnet Synchronous Generator.
* Wind mill tower height 12 feet with stay wire.

3. DUAL CORE DELFINO BASED DEVELOPMENT BOARD (MICRO 28377D)

The Micro-28377D Trainer kit is intended and developed for advanced closed-loop control applications for Power electronics, Smart grid etc.., It is also focused for students to learn the multi-processor architecture and the inter processor communication mechanisms. The inbuilt peripherals of the processor lead to uncomplicated design for the developers in the emerging technology. The onboard Delta Sigma modulator meant for current measurement of Power electronics, Drives, Smart grid & Power systems.

Features:

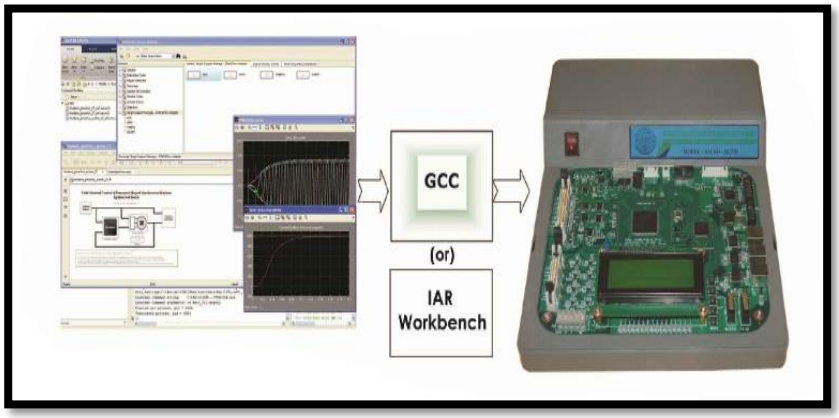
Dual- Core 32-bit Delfino fixed point Processor
Operating Speed: 200MHz (For each core)
32-bit floating-point unit (FPU) which supports floating point operations
- Trigonometric Math Unit (TMU) to speed up the execution of trigonometric Operations
- Viterbi, Complex Math, and CRC Unit II (VCU-II) to accelerate the performance of FFT's and communications-based algorithms
- Two CLA real-time control co-processors that run at the same speed as the main CPU'sParallel processing capability effectively doubles the computational performance
1MB (512KW) of onboard flash memory with error correction code (ECC)
204KB (102KW) of SRAM
- 16 Channels (16-bit/12-bit at 1.1 MSPS/3.5 MSPS) Successive Approximation ADCs
16 Enhanced PWM outputs, 6 Enhanced Capture Inputs
- 3 (12-bit) Buffered DACs & 2 SDFM with 8 Input Channels and PWM
synchronization
External memory interface 16/32 bit support
192 dedicated PIE vectors
MCU/DSP balancing code density & execution time
Single cycle read-modify-write instruction.

ON Board Features:

* 16 Numbers of user LEDs
* 2 Numbers of Limit Switches for user interface

* 4 Numbers of Push-Button Micro Switches
* 1 SPDT Switch for user interface
* 20 × 4 Alphanumeric LCD
* 256MB of SDRAM
* Quadrature Encoder Interface
* Opto-isolated USB Interface
* Opto-isolated USB to Serial Interface
* Opto-isolated on board USB to JTAG Emulator

- PWM Outputs and Capture Inputs are terminated at 34-pin FRC connector
- 16 Channel ADC inputs are terminated at 26-pin FRC connector with buffered and protection
- DAC outputs and sigma Delta ADC inputs are terminated in screw type connector.
- External Emulator facility.
- Compatible with MATLAB SIMULINK



Battery Charging Section

a. Power Circuit

- One LEG of 2 IGBT provided for Charging the Battery in BUCK Mode
- IGBT will act in BOOST Mode and converts the Battery Voltage of 240V DC to 350V DC Bus.

b. 12V Battery Bank - 12Vx7AH x 20 Nos

- 12V / 7AH - 20Nos connected in Series
- 120 volt output to the Inverter.

. 1680 Watts Output.

External battery Charger:

- Output Voltage: FLOAT 240V .
- 5Ampere Output
- Input Voltage: 170-270VAC
- Operating Temperature: (-20) TO (+85) DEGC
- Output Current: FLOAT 0-3 A, BOOST 3-10 A
- Usage/Application: LED ACID BATTERY CHARGER
- Current Controller Knob

- Ammeter Display
- Crocodile Connector with wire 2ft in length

5. Solar Array Simulator - 500W

- Input voltage range : 250V AC @50HZ
- Power Ratings : 500W (max)
- Max. power : 500W
- Open circuit voltage Voc : 0-60V
- Short Circuit Current Isc : 0-10A
- Peak power Voltage Vm : 0-55V
- Peak power Current Im : 0-9A Interface
- USB Interface with PC based GUI Software

* Realtime Simulation of IV & PV Characteristics

6. Wind Turbine Simulator - 500W

- Input voltage range : 250V AC @50HZ
- Power Ratings : 500W (max)
- Max. power : 500W
- Open circuit voltage Voc : 0-60V
- Short Circuit Current Isc : 0-10A
- Peak power Voltage Vm : 0-55V
- Peak power Current Im : 0-9A Interface
- USB Interface with PC based GUI Software

* Realtime Simulation of IV & PV Characteristics

7. Wind Turbine Emulator - 500W

A 1hp Induction Motor Coupled with 500W PMSG Generator, VFD and DSP Controller Provided to Emulate a Wind Turbine

- 1HP Inductiom Motor
- 1HP VFD for Variable speed control of IM.
- 500W PMSG Generator.
- Output : 0-220V, AC, 3Φ
- Power Ratings : 500W (max)
- Max. power : 500W

* Realtime Simulation of IV & PV Characteristics