8.Advanced solar wind Grid connected 3ϕ,2KW smart Grid xperiment Setup

Advanced Solar Wind Grid Connected 3Φ, 2KW Smart Grid Experimental Setup

This consists of 2 Microgrids of 2000 watts and 1000 watts of power generation connected to a main Power Grid with all the components needed to convert a traditional Grid to a Smart Grid so that many experiments can be conducted on this "Smart Grid". A 3Φ 3KW isolation transformer with power input from utility grid will act as main grid to which 2 Microgrid will be connected through synchronizing panel. Optionally a commercial 3Φ, 2.5KVA Grid Commercial Solar Power Inverter can be added to this experimental setup.

By adding 3Φ, 2.5KVA commercial solar inverter, when the experimental setup is not used by student, it could be used to generate power.

This Advanced Smart Grid Experimental Setup Consists of

I) 2 Micro Grids, each 1000 watts of power generation using Solar, Wind or Hybrid
II) An Isolation Transformer Coupled to the utility Grid, acts as Main Grid to this Setup
III) Various other Power Sources
IV) Commercial 3Φ 5KVA Grid Connected Inverter (Optional)
V) Optional Components for the Smart Grid Setup
VI) DSP /FPGA Controller for PE, SG, PS Applications
VII) Other Add ons
VIII) Components for Building 10/25KW Smart Grid Power Generation
IX) IoT Based Data Acquisition.

I) i. Micro Grid -I

(Solar Wind Grid Connected 3Φ, 2KW Smart Micro Grid)

1. Main Frame
2. 1KW Solar PV Module with Stand
3. Wind Turbine
   a) 1KW Wind Turbine with Tower
   (or)
   b) 300W Wind Turbine with Blower setup
4. DC-DC Boost Converter
   a) 2KW Hybrid DC-DC Buck-Boost Converter
   (or)
   b1) 1KW DC-DC Boost Converter for Solar (or)
   b2) 1KW DC-DC Boost Converter for Wind
5. 120V Battery Bank - 12V x 100AH x 10 Nos
6. 2KW Bi-Directional DC-DC Buck-Boost Converter for Charging battery
7. 2KW 3Φ Inverters
   a) 2KW 3Φ 2 level Inverter
   (or)
   b) 2KW 3Φ 3 Level Inverter
8. DSP/FPGA Controller
9. Microcontroller based Protection Relays
10. Smart Energy Meter
11. Synchronizing Panel
12. Three Phase RL Load 2KW
13. PLC with SCADA Software
14. 14 Channel PC based Power Quality Analyzer (Optional)

ii. Micro Grid -II

(Solar Grid Connected 3Φ, 1KW Smart Micro Grid)

1. Main Frame
2. 1KW Solar PV Module with Stand
3. 1KW DC-DC Buck-Boost Converter
4. 120V Battery Bank - 12V x 100AH x 10 Nos
5. 1KW Bi-Directional DC-DC Buck-Boost Converter
6. 2KW 3Φ Inverters
   a) 2KW 3Φ 2 level Inverter
   (or)
   b) 2KW 3Φ 3 Level Inverter (Optional)
7. DSP/FPGA Controller
8. Microcontroller based Protection Relays
9. Smart Energy Meter
10. Synchronizing Panel
11. Three Phase RL Load 2KW

II) An Isolation Transformer Coupled to the utility Grid, acts as Main Grid to this Setup

Three phase 3KVA isolation transformer with power input from utility grid will act as main grid to which 2 microgrids and commercial grid connected solar inverter etc will be connected through synchronizing panel

III) Various Other Power Sources

i) A Three Phase Power Source
ii) 2KW DFIG Setup with 5KVA IGBT based Converter - Inverter System
iii) 2HP DC motor coupled with 3Ø 1KVA Alternator based Power Source

IV) Commercial 3Φ 2.5KVA Grid Connected Inverter (Optional)

V) Optional Components for the Smart Grid Setup

a. 300watts Wind Turbine with Blower
b. Solar Array Simulator (500W)
c. Wind Turbine Simulator using 3HP DC motor Coupled with 1KW PMSG
d. Weather Station

VI) DSP /FPGA Controller for PE, SG, PS Applications

i) dsPIC 33EF814 Controller
ii) TMS320F28335 DSP Controller
iii) Piccolo DSP Controller
iv) Spartan-6 FPGA Controller
v) Advanced Cyclone-IV FPGA Controller
vi) Cyclone-IV Based FPGA Controller
vii) St-Cortex-M4 Controller Board
viii) Dual Core Delfino DSP Controller

VII) Smart Grid Simulator

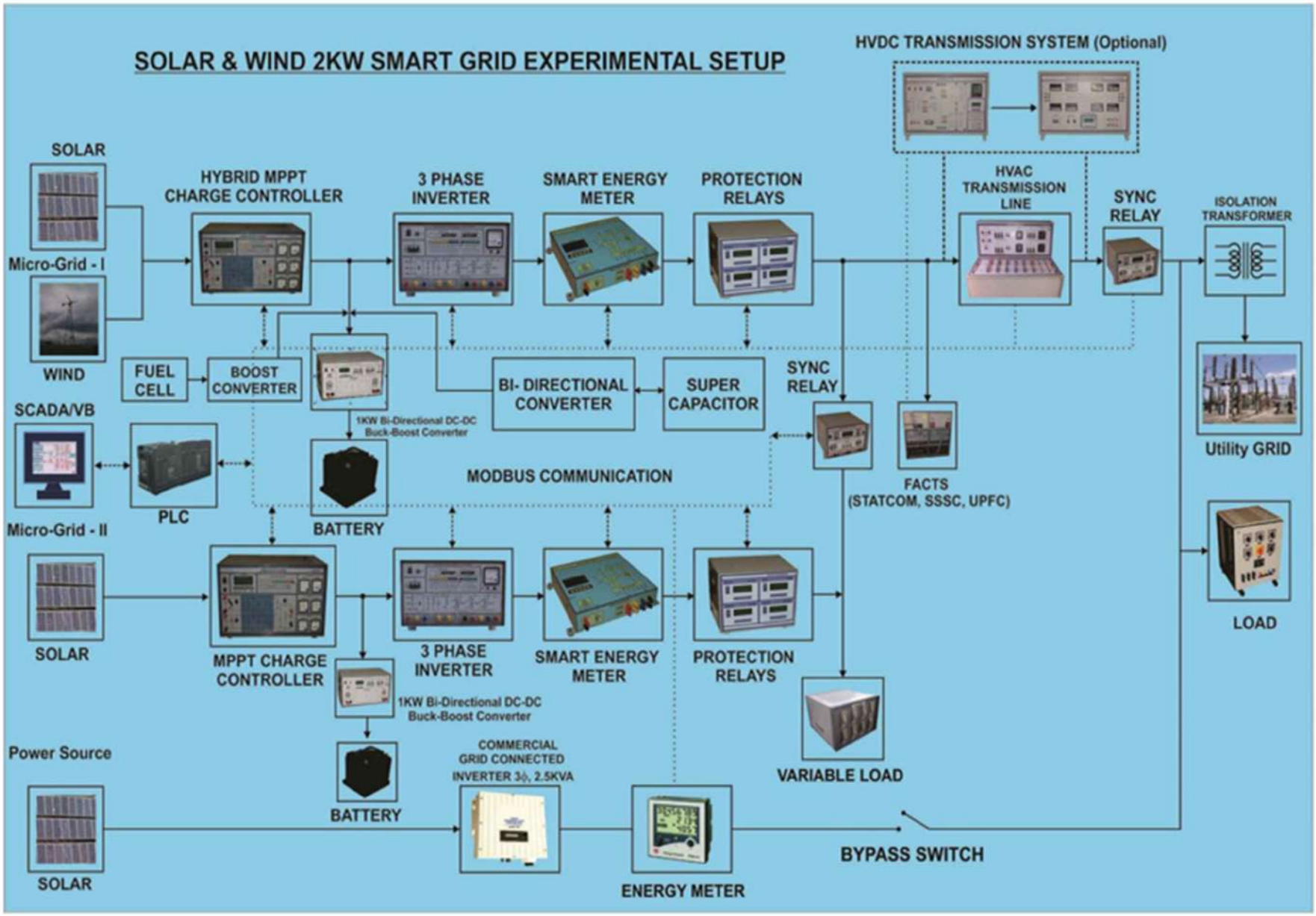
VIII) Components for Building 10/25KW Smart Grid Power Generation

i) 10KW IGBT Based Power Module
ii) 25KW Power Module for Multilevel Inverter

IX) IoT Based Data Acquisition

X) Other Add ons

i) Fuel Cell
ii) Super Capacitor
iii) Load Controller
iv) Battery Charger

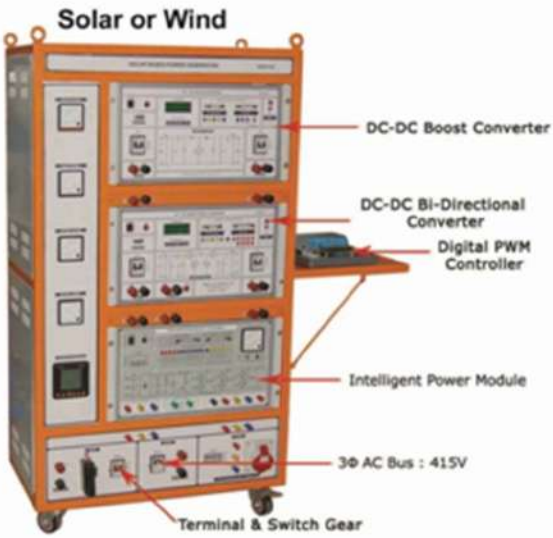

SOLAR & WIND 2KW SMART GRID EXPERIMENTAL SETUP
HVDC TRANSMISSION SYSTEM (Optional)
SOLAR
Micro-Grid - I
WIND
HYBRID MPPT CHARGE CONTROLLER
3 PHASE INVERTER
SMART ENERGY METER
PROTECTION RELAYS
HVAC TRANSMISSION LINE
SYNC RELAY
ISOLATION TRANSFORMER
Utility GRID
FUEL CELL
BOOST CONVERTER
1KW Bi-Directional DC-DC Buck-Boost Converter
BI- DIRECTIONAL CONVERTER
SUPER CAPACITOR
SYNC RELAY
SCADA/VB
PLC
BATTERY
MODBUS COMMUNICATION
FACTS (STATCOM, SSSC, UPFC)
Micro-Grid - II
SOLAR
MPPT CHARGE CONTROLLER
3 PHASE INVERTER
SMART ENERGY METER
PROTECTION RELAYS
LOAD
1KW Bi-Directional DC-DC Buck-Boost Converter
VARIABLE LOAD
Power Source
BATTERY
COMMERCIAL GRID CONNECTED INVERTER 3ϕ, 2.5KVA
SOLAR
ENERGY METER
BYPASS SWITCH

I) i & ii) SOLAR WIND GRID CONNECTED 3Φ, 2KW SMART MICRO GRID

Smart Grid getting popular every year. Power Sources form solar and wind are also becoming popular due to lot of technology evolvement. Hence a laboratory setup of "Solar and Wind based Smart Grid" which consists of all components of Smart Grid like MPPT based DC-DC converter, 3 phase inverter, switch Gear with modbus communication, 3Φ Artificial Transmission line, FACTS model, HVDC model, Load etc.,

This unit consists of

1. Main Frame
2. 1KW Solar PV Module with Stand
3. Wind Turbine
   a) 1KW Wind Turbine with Tower
   (or)
   b) 300W wind Turbine with Blower setup
4. DC-DC Boost Converter
   a) 2KW Hybrid DC-DC Boost Converter
   (or)
   b1) 1KW DC-DC Boost Converter for Solar
   (or)
   b2) 1KW DC-DC Boost Converter for Wind
5. 120V Battery Bank - 12V x 100AH x 10 Nos
6. 2KW Bi-Directional DC-DC Buck-Boost Converter for Charging battery
7. 2KW 3Φ Inverters
   a) 2KW 3Φ 2 level Inverter
   (or)
   b) 2KW 3Φ 3 Level Inverter
8. DSP/FPGA Controller
9. Microcontroller based Protection Relays
10. Smart Energy Meter
11. Synchronizing Panel
12. Three Phase RL Load 2KW
13. PLC with SCADA Software
14. 14 Channel PC based Power Quality Analyzer (Optional)



Hybrid

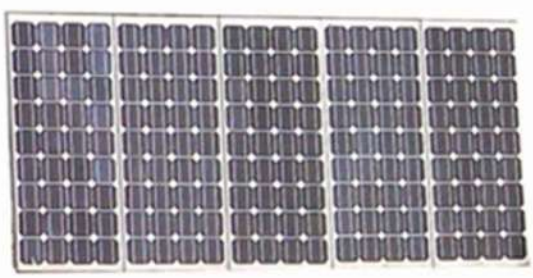
Technical Details as below

1. Main Frame

* Designed to house all the modules
* DPMs fixed on the Front Panel
  # Voltage for Solar & Battery
  # Current of Solar & Battery
  # 1no of multifunction meter for inverter output
* One LC filter provided at the Inverter output
* One step-up transformer provided the output of inverter
* Termination provided for solar input with MCB & Fuse Protection.
* Termination provided for Battery input with MCB & Fuse Protection.
* 1no of industrial power socket provided for inverter output with MCB Protection.
* External 230V AC 1Φ required to meet the power supply of control circuits.

2. 1KW Solar PV Module with Stand

*	Make	: Reputed approved by MNRI
*	No of Panels	: For 1KW, 100W - 10Nos.
*	Peak Power of Module	: 1000 Watts
*	Temperature	: -40 to 90˚c
*	Wind Load	: UP to 200kmph
*	Humidity	: 0 to 100%
*	Type of cell	: Poly crystalline silicon
*	Lamination Type	: Vacume Laminated Glass to ladler
*	Voc of each module	: 21 Volts
*	Voc of 1KW setup	: 210 Volts

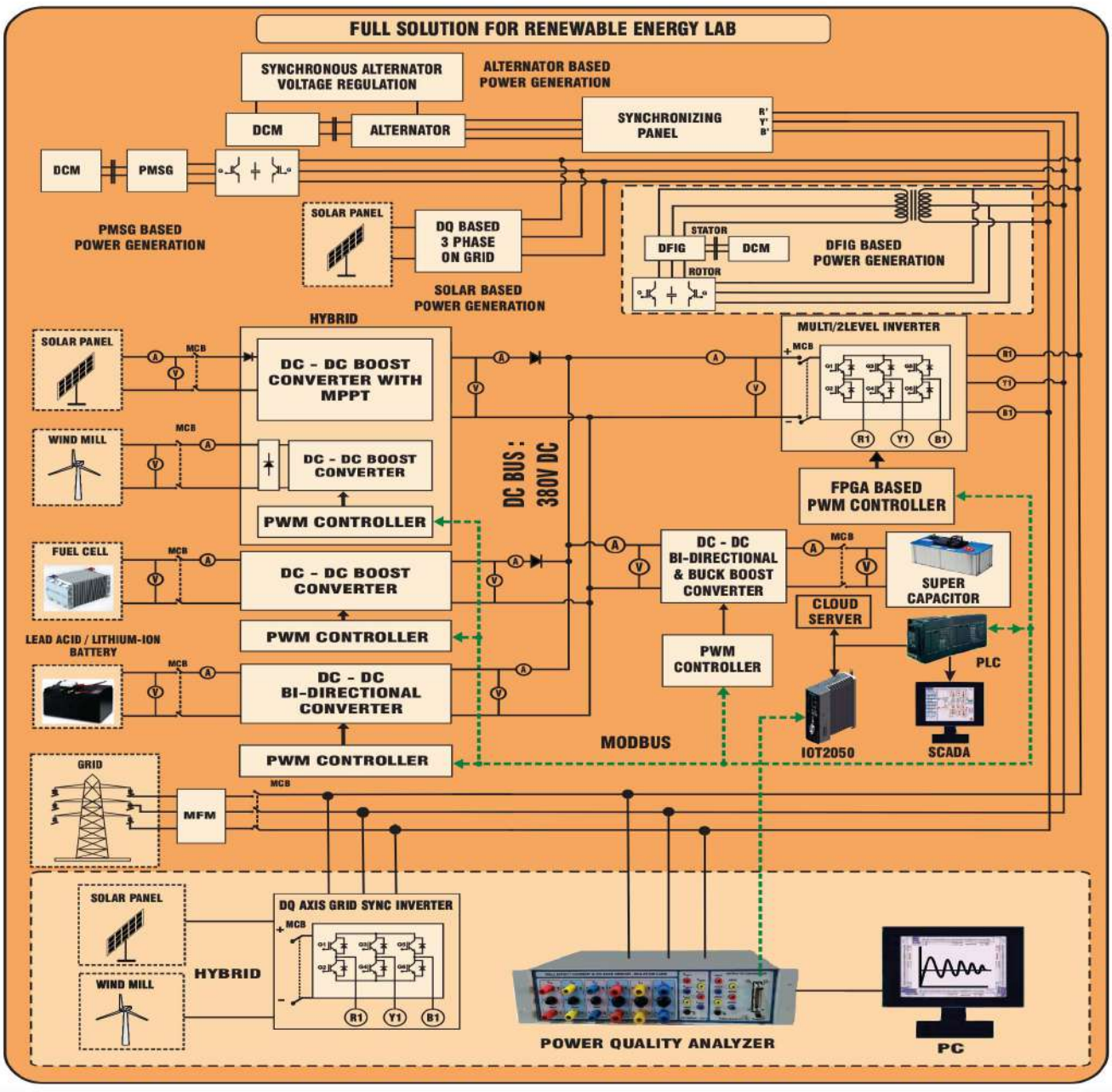


3. Wind Turbine

a) 1KW Wind Turbine with Tower

- 48V Wind Generation
- 1KW Wind Turbine
- Three Blades
- Nominal Voltage 48V
- Maximum Power 1000W
- Start Wind speed 2m/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 Fiber
- Generator : Three phase Permanent magnet synchronous generator



b. 300W Wind Turbine with Blower Setup

Performance Parameter

* Rated Electrical Power : 1KW@8.2m/s
* Rated Wind Speed : 11.5m/s
* Cut-in : 3.5m/s
* Shut-down (High Wind) : 23m/s
* Peak (Survival) : 60m/s

Rotor

* Type of Hub : Fixed pitch
* Rotor Diameter : 1.5m
* Swept Area : 12.5m2
* Number of Blades : 3
* Rotor Speed @ rated wind speed : 250 RPM
* Location Relative to tower : UP wind
* Rotor Tip Speed : 52m/s
* Design Tip Speed : 7.00

Blade

* Material : Glass Fiber
* Airfoil (type) : NACA 23015 modified
* Twist : 14° outer blade
* Blade Trailing Edge : Parabolic

4. DC-DC Buck-Boost Converter

a) 2KW Hybrid DC-DC Buck-Boost Converter

* Microcontroller based Buck-Boost with MPPT algorithm
* Switching device IGBT
* I/P voltage range
  # 120V DC-210V DC
* O/P voltage range
  # 380V DC / 3A
* All the I/P & O/P are sensed through isolated sensors
* 4Nos of ADC feedback provided to sense
  - I/P Voltage of Solar, I/P Current of Solar
  - O/P Voltage & Current of Converer
* Proper termination provided for input & output with MCB protection.
* 4 keys provided to select the type of control program
* 20x4 LCD displays all the I/P / O/P datas
* Over current, over voltage & temperature protection.
* 34pin FRC & 26 pin FRC provided for external controller interface.
* dv/dt protection is available for IGBT (Snubber Circuit)
* One RS232/RS485 port provided to Interface with PC/PLC

b1) 1KW DC-DC Boost Converter for Solar

* Microcontroller based Boost with MPPT algorithm
* Switching device IGBT (Semikron)
* I/P voltage range : 120V, -210V DC
* O/P voltage range : 380V DC / 3A
* All the I/P & O/P are sensed through isolated sensors
* 4Nos of ADC feedback provided to sense
  - I/P Voltage of Solar, I/P Current of Solar
  - O/P Voltage & Current of Converer
* 4 keys provided to select the type of control program
* Banana connector termination provided for input & output with MCB protection.
* 20x4 LCD displays all the I/P / O/P datas
* Over current, over voltage & temperature protection.
* 34pin FRC & 26 pin FRC provided for external controller interface.
* dv/dt protection is available for IGBT (Snubber Circuit)
* One RS232/RS485 port provided to Interface with PC/PLC

b2) 1KW DC-DC Boost Converter for Wind

* Microcontroller based Boost with MPPT algorithm
* Switching device IGBT (Semikron)
* I/P voltage range : 120V DC-210V DC
* O/P voltage range : 380V DC / 3A
* All the I/P & O/P are sensed through isolated sensors
* 4Nos of ADC feedback provided to sense
  - I/P Voltage of Solar, I/P Current of Solar
  - O/P Voltage & Current of Converer
* Proper termination provided for input & output with MCB protection.
* 4 keys provided to select the type of control program
* 20x4 LCD displays all the I/P / O/P datas
* Over current, over voltage & temperature protection.
* 34pin FRC & 26 pin FRC provided for external controller interface.
* dv/dt protection is available for IGBT (Snubber Circuit)
* One RS232/RS485 port provided to Interface with PC/PLC

5. Battery Bank - 12V/100AH x 10 Nos

* 12V / 100AH - 10Nos connected in series.
* 120 volt output to the Inverter.
* Ammeter, Voltmeter, MCB provided in the stand
* Maintenance free battery
* Battery Stand with wheel arrangement

6. 2KW Bi-Directional DC-DC Buck-Boost Converter for Charging Battery

* Microcontroller based DC - DC Controller
* 2 Nos of High Speed MOSFET / IGBT
* 2 Nos of Isolated High Speed Driver circuits
* 2 Nos of Current Sensor for sensing the input and output current of the converter
* 2 Nos of Voltage Sensor for sensing the input and output voltage of the converter
* In Boost mode I/P is 120V and O/P is 380V DC
* In Buck mode I/P is 380V and O/P is 120V DC
* Power Rating is 2000Watts
* dv/dt protection is available for all MOSFET (Snubber Circuit)
* 20x4 Alpha Numeric LCD display
* One RS232/RS485 provided to Interface PC or PLC
* Test points provided in control section for wave form measurement in CRO

7. 2KW 3Φ Inverters

a) 2KW 3Φ 2 Level Inverter

* I/P Voltage : 380V DC
* O/P Voltage: 415V AC / 1KVA (max)
* Sine wave output (LC Filter)
* 34pin FRC & 24 pin FRC provided for controller interface
* 6 Numbers of High speed Opto - isolator provided for PWM isolation
* 6 Number of IGBT with Heat sink provided as power circuit
* Hall Effect current sensor provided for output current & DC current measurement & protection
* 1no of hall effect voltage sensor provided for input DC voltage measurement and protection.
* Op-amp signal conditioner circuit provided for current, voltage sensors & output terminated in front panel for measurement.
* Over current / voltage / Temperature Trip circuit provided for protection.
* One number of LED provided to indicate TRIP Status
* One number of Reset Switch provided to reset the Trip Function
* Test points provided for PWM & Current, Voltage wave form measurement in CRO

Note: One DSP/FPGA controller needed externally.

b) 2KW 3Φ 3 Level Inverter

* I/P Voltage : 380V DC
* O/P Voltage: 415V AC / 1KVA (max)
* Sine wave output (LC Filter)
* 34 pin FRC & 26 pin FRC provided for controller interface
* 12 Numbers of High speed Opto - isolator provided for PWM isolation
* 12 nos of IGBT 1200V / 25A / 50A into 6 IGBT modules. Each leg having 2 IGBT modules. 3 legs form 3 phase Multilevel Power Circuit.
* 6 nos of Diodes 1200V/25A/50A into 3 diode modules are connected across each leg to form Diode Clamped Multilevel Inverter.
* Hall Effect Voltage Sensor provided for DC Voltage measurement & protection
* Hall Effect current sensor provided for output current & DC current measurement & protection
* Op-amp signal conditioner circuit provided for current sensors & output terminated in front panel for current wave measurement.
* Over current Trip circuit provided for over load protection.
* One number of LED provided to indicate TRIP Status
* One number of Reset Switch provided to reset the Trip Function
* Test points provided in control section for wave form measurement in CRO

Note : One DSP/FPGA Controller needed externally

8. DSP/FPGA Controller

One of these controllers should be purchased to drive Inverter

a) dsPIC 30F4011 Based Controller (Not Suitable for 3 level inverter)

Microchips dsPIC30F4011 16 Bit digital signal controller operating at 20 MIPS

Memory On Chip:

* 48KB Flash Program Memory
* 1KB Data EEPROM
* 24KB RAM for data Memory

PWM Capture & Timers

* 16 bit timer / Counter
* 6 motor control / PWMs with Programmable dead band terminated at 34 pin FRC Connector
* 2 capture inputs terminated at 34 Pin FRC connector
* 1 Quadrature encoder interface terminated at 34 Pin FRC Connector

ADC & DAC

* 6 channel 10 bit, 0-5V ADC buffered and terminated at 26 pin FRC connector
* 4 Channel 12 bit , 0-5V ADC external DAC provided and terminated at 26 pin FRC connector

LCD, Keypad & Serial Port

* 20x4 Alphanumeric LCD display
* 3 switches provided for user inputs
* Reset switch provided for hardware reset
* One UART is terminated at 9 Pin Connector (RS232) it can operate up to 115200bps Baud rate

Power Supply

* Input : 230V / 50Hz AC
* Output :+5V / 3A & ± 12 V/ 500mA

b) SPARTAN 6 FPGA Controller (VPE-SPARTAN 6)

* XC6SLX25-2FT256
* 136kB Distributed RAM
* 576Kb Block RAM
* 8 User LEDs, Switches
* Opto Isolated USB - Serial Port
* 20x4 Alpha numeric LCD display
* PE & Drives compactable Signals Terminated at 34 pin FRC connector
  - # 16 motor control PWM with Programmable dead band signals
  - # 8 captures input signals
  - # 1 Quadrature encoder interface
* ADC Signals Terminated at 26 pin FRC connector
  - # 8 channel 12 Bit ADC
  - # 2 MSPS Sampling rate
* 4 Channel DAC terminated at J801 Connector
* 2 Limit switches are provided for General purpose usage in the software. (Factory configured as Increment, Decrement switches)

c) TMS320F28335 Based DSP Controller

- Processor: TMS320F28335 floating point
- Operating Speed: 150MHz
- 256KB on chip Flash Memory
- 34KB on chip SARAM
- 256KB external RAM for program / data
- On board isolated USB-JTAG emulator
- 20x4 LCD interface
- Opto Isolated onboard USB to Serial port
- 34 pin Interface connector for motor control
  - # 18 Motor Control PWM
  - # 6 capture I/P signals
  - # 2 Quadrature Encoder Interface
- 26 pin ADC I/F connector
- 4 channel 12 bit DAC terminated at J801 connector

d) CYCLONE IV FPGA Controller (VPE-CYIV)

- Based on Altera family Cyclone IV, Device : EP4CE30
- One 34 pin header used for IPM Interface.
  - 16 PWM output
  - 8 capture inputs.
- One 26 pin header ADC.
  - 4 channel 1MSPS ADC.
  - Total 8 channel using 2 Nos of ADC.
  - 12 bit resolution.
  - Input range -10V to 10V / -5V to 5V. (Software Programable)
- One 5 pin phoenix connector DAC
  - 4 channel DAC, 12 bit resolution.
  - Output range -10V to 10V / -5V to 5V. (Software Programable)
- 8 output Light Emitting Diodes (LEDs).
- 8 input slide Switches.
- 4 user push button switches.
- 2-user limit switch.
- 20 x 4 Alphanumeric LCD display.

e) Advanced Cyclone - IV FPGA Controller (VPE-CYIVAD)

- Based on Altera family Cyclone - IV
- 8 User LEDs & Switches
- 20 x 4 Alpha numeric LCD display
- One isolated USB to serial port
- 2 limit switches are provided for general purpose usage in the software
- Termination of 84 PWMs at 5V level in 2nos of 50 pin FRC connector
- PE & Drives compatible signals terminated at 34 pin FRC connector
  - # PWM outputs are terminated at 34 pin FRC connector
  - # 16 motor control PWM with programmable dead band signals
  - # 8 captures input signals / 1 quadrature encoder interface
- ADC signals terminated at 26 pin FRC connector
  - # 16 Channel ADC inputs
  - # 1 MSPS sampling rate
  - # Input Range : ±10V, ±5V programmable
- DAC outputs terminated at J801 connector
  - # 4 channel DAC output
  - # Output range : ±10V, ±5V programmable
- On board isolated USB to JTAG port
- On board USB 2.0 interface with TMC standard
- Unique Features

11. Synchronizing Panel

- It synchronizes inverter output and grid input. It sense inverter voltage, phase and frequency as well as grid voltage, grid phase and frequency
- 16bit microcontroller provided to measure current & voltages and controlling all operation.
- 20x4 LCD Display to display voltages phase & frequency.
- Front panel have two 3pole MCB to switch ON/OFF the grid and inverter voltage inputs.
- One contactor provides to automatic synchronizing grid and inverter
- Contactor current rating: 16 A/4 pole
- 6 voltage signal Conditioner provided to measure the voltages
- 6No's of ZCD provided to sense the frequency as well as phase
- Input and output terminated at proper terminals

12. Three Phase RL Load (2KW)

a. Three Phase Inductive Load
- 120mH, 4Amp rating - 3Nos
- With 0, 12,24,36,60,90,108, 120mH tapping
- Iron core type
- Banana connector provided for all inputs

b. Lamp Load (1KW)
- Different Switches provided for selection of load
- Enclosed in a powder coated cabinet

c. Resistive Load (1KW)
- Different Switches provided for selection of load
- Enclosed in a powder coated cabinet

13. PLC with SCADA Software (VPST-100HVSC-F)

This consist of
i. PLC with MODBUS
ii. PLC Programming Software
iii. SCADA Software (Simatic WinCC Flexible)
iv. Application Software for SCADA Software

The PLC with MODBUS Communication can interface with all the Intelligent Electronic Devices (IEDs) which in turn can be connected to SCADA Software for better monitoring and controlling of the "Smart Grid".

i. PLC with MODBUS
- Make : Siemens,
- Model : CPU 1212C – DC / DC / DC
- PLC : S7-1200
- Bit processing speed 0.1 micro
- Ethernet communication interface (TCP/IP Native, ISO on TCP)
- In built Real Time Clock
- This PLC acts as Master for Serial Communication in MODBUS Protocol
- MODBUS is used to communicates Master (PLC) and Slaves (RTU)

ii. PLC Programming Software
- Windows based powerful software provided to write program in Ladder Language & FBD (Function Block Diagram)
- Siemens PLC programming software, IEC 61131 standard
- Simatic Step 7 - Version 12 software has been used for develop the functional blocks and ladder diagram programming in PLC S7-1200

iii. SCADA Software (Simatic WinCC Flexible)

* Wincc - Flexible 2008 - SP3 has been used for developed the graphical representation, Analysation & control for process in SCADA
* To study SCADA principle simatic its applications in Power Systems we offer most popular Supervisory Control (SCADA) package "Simatic WinCC Flexible" from SIEMENS. This is very rich in feature and offers all drivers to interface with any PLC available in the market.
* The SCADA software can access all data from PLC through Ethernet where PLC communicates with RTU device through MODBUS protocol

iv. Application Software for SCADA software

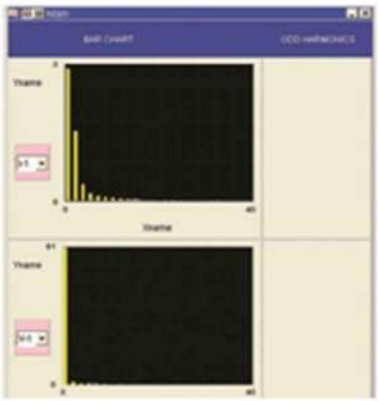
* SCADA Based Applications software written to integrate
  # Hybrid DC-DC Buck-Boost Converter
  # Bi-Directional Buck-Boost Converter
  # 2KW Inverters
  # DSP/FPGA Controller
  # Microcontroller based Protection Relays
  # Synchronizing Panel

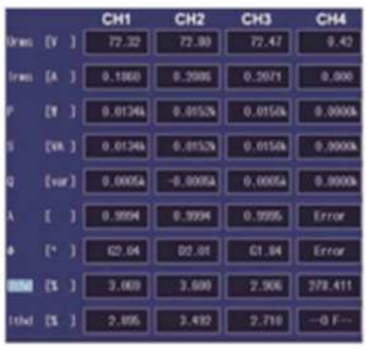
NOTE:

* All civil and wiring works should be taken care by the customer during the installation
* Wind velocity to be measured by customer before order

14. 14Channel, PC based Power Quality Analyzer (Optional)

* Based on FPGA based DAS for 14 channel with signal conditioners
* 7 no's of Hall Effect Current Sensors for AC/DC current measurement
* 7 no's of Hall Effect Voltage Sensors for AC/DC voltage measurement
* 14 Channel will be useful to analyze a 3Φ inverter i) Input 3Φ Voltages & Currents ii) Output 3Φ Voltages & Currents iii) DC Link Voltage & Current
* VEE PRO based runtime environment will be provided.
* Provided with Laptop with Windows7.





II) An Isolation Transformer Coupled to the utility Grid, acts as main Grid to this Setup

Three phase 3KVA isolation transformer with power input from utility grid will act as main grid to which 2 microgrids and commercial grid connected solar inverter etc will be connected through synchronizing panell

III) Various Other Power Sources

i) A Three Phase Power Sources

This unit is used to generate 3phase output with frequency and voltage controllable. The output voltage can vary from 48Hz to 52Hz.
It consists of one controller to generate PWM for voltage Source and one 3 phase voltage source inverter power module.

* dsPIC4011 based controller to generates PWM.
* IPM based Power module for voltage source inverter
* Output is filtered and isolated through LC and isolation transformer.
* MFM provided to read all the output parameter
* MCB provided to switch ON/OFF the Power Source
* Safety Power socket provided to give input and output.
* Input 3phase/440V AC/50Hz
* Output variable 440V AC/ 1KW. Variable frequency 48Hz to 52Hz.

ii) 2KW DFIG Setup with 5KVA IGBT based converter - Inverter System

a) Dc motor Coupled with 2KW Slip Ring Induction Motor
b) dsPIC30F4011 based PWM Controller
c) Power Module for DC Drive
d) Power Module for Doubly Fed Induction Generator
e) TMS320F28335 based DSP Controller (Micro - 28335)

(Refer Page : 18)

iii) 2HP DC Motor Coupled with 3Ø 1KVA Alternator based Power Source

* Proximity sensor provided as speed sensor
* Converter with 6 IGBT provided to from 3 legs for control the power source.
* 2 Leg to from H Bridge to control the armature of DC motor.
* One Leg to generate variable DC voltage for field coil of alternator
* Dspic4011 based open & closed loop control of DC motor.
* Over current protection provided
* Switches provided for increase & Decrease the speed.

IV)Commercial 3Φ 2.5KVA Grid Connected Inverter (Optional)

* Solar Module : 1020W
* Grid - tie Inverter - 2.5KVA
* Solar Panel
* AC Distribution box

V) Optional Components for the Smart Grid Setup

a. 300 Watts Wind Turbine with Blower

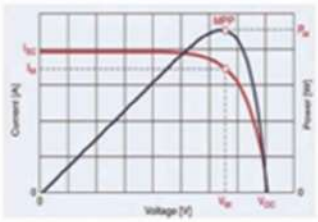
* 300W PMSG Wind Turbine provided
* Wind Turbine & Generator Fixed in a mechanical frame
* Safety grill arrangement provided to avoid physical damage to the student
* 1 no of Blower provided as Wind Blower for indoor power generator & Experimentation.
* Maximum Output in MPPT mode : 300W
* Continuous Power Delivery : 300W

b. Solar/Wind Array Simulator

Input voltage range : 250V AC @50HZ
Power Ratings : 500W (max)

* Max. power : 500W
* Open circuit voltage Voc : 0-60V
* Short Circuit Current Isc : 0-20A
* Peak power Voltage Vm : 0-55V
* Peak power Current Im : 0-18A

Solar Array Simulator IV & PV Curves



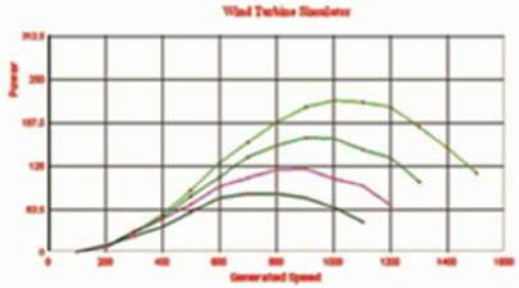
Interface

* USB Interface with PC based VB-GUI
* Realtime Simulation of IV & PV Characteristics.

c. Wind Turbine Simulator using DC Motor Coupled with PMSG

Wind Power Generation gaining importance for its advantage. As a result, a great deal of Research and Laboratory experiments have been focused at the college level. The investigation of Wind Power Generation may not be possible by installing a Real Wind Turbine Tower at all Institutions in India, where sufficient wind speed may not be there and wind speed is also seasonal, which leads to the need of a "Wind Turbine Simulator" at the college.

The PMSG Wind Turbine Simulator has been designed such that it's Static and Dynamic characteristic is as close to Real Wind Turbine. This Simulator consists of a DC shunt motor, a PMSG, TMS320F28335 based DC chopper etc to simulate the Wind Turbine



It Consists of,

a. TMS320F28335 Based DSP Controller
b. IPM Based Power Module (3hp) for PMSG - 2 Nos
c. 1 HP DC Shunt Motor Coupled with 1HP PMSG Motor with Sensor
d. Prime over drive

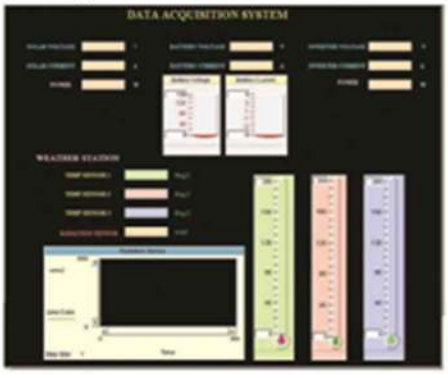
d) Weather Station Experimental Setup

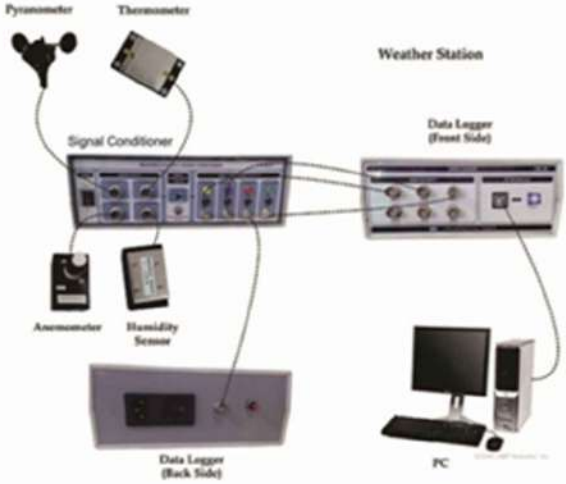
This setup is used to sense and plot various Parameters like Temperature, Humidity, wind speed and solar radiation. This unit consists of High speed Data Acquisition, Temperature, Humidity, Hall Effect, Wind Anemometer and pyranometer sensor and its signal conditioner.

SENSOR MODULES

i. Hall Effect Wind Anemometer

* Polycarbonate, 3-cup anemomenter, which is calibrated.
* Uses a Hall Effect Digital Switch to directly drive digital circuitry.
* Producer pulse based on input voltage.
* Swept Diameter : 7.5"
* Diameter Housing : 2.0"
* Overall Height : 3.2"
* Weight : 3.0 oz





ii. Temperature Sensor module

* Temperature sensor by using glass bead thermistor
* Output in 5 pin socket

iii. Humidity Sensor

* Senses the Humidity of the Atmosphere
* Output in mic socket

iv. Pyramo Meter Sensor

* Measures the Atmosphere Pressure
* Output in mic socket

SIGNAL CONDITIONER MODULE

A separate Signal Conditioner module provided to signal conditon various sensor & outputs.

* It consists of 4 input terminals in 5 pin mic socket
* 4nos of output terminals in BNC female connector
* One no of ON/OFF switch (IRS)
* 8Nos BS2 connectors to read the signals in scope
* The conditioned output are applied to the Data Logger

DATA LOGGER

* It is used to interface the PC and signal conditioner
* 6 Analog input terminals in BNC female connector
* One USB port to interface PC front end GUI
* One Digital input at the Back side and BNC female connector termination.

GUI

* VEEPRO based front END GUI

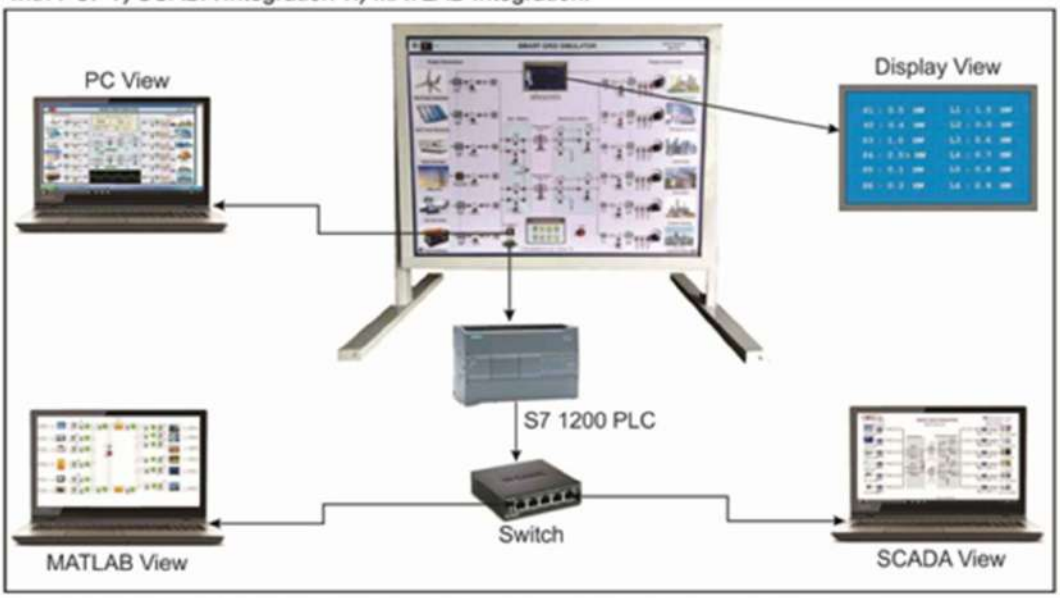
VI) DSP /FPGA Controller for PE, SG, PS Applications

i) dsPIC 33EF814 Controller
ii) TMS320F28335 DSP Controller
iii) Piccolo DSP Controller
iv) Spartan-6 FPGA Controller
v) Advanced Cyclone-IV FPGA Controller
vi) Cyclone-IV Based FPGA Controller
vii) St-Cortex-M4 Controller Board
viii) Dual Core Delfino DSP Controller

(Refere Page No. 39)

VII) SMART GRID SIMULATOR (VPST-SGS-01)

Smart Grid Simulator (VPST-SGS-01) is a convenient solution for studying the basic Architecture. As Smart Grid is gaining momentum in Power Generation, Transmission Line & Distribution, Vi Micro has designed a simple system which can simulate a Smart Grid. It consists of i) 6 types of Generation ii) 2 Nos Transmission Line iii) Six types of loads iv) Communication through USB with PC. v) SCADA Integration vi) MATLAB Integration.



All the components are mounted in a powder coated metal box with stand and stickered front plate.

Features

- MODBUS interface with PLC, Ethernet interface with SCADA & MATLAB.
- Six different generating simulated station (up to 5MW)-Wind, Solar, Diesel, Bio-Gas, Fuel-Cell & UtilityGrid.
- Two separate Transmission Lines (2.5 MW Each) – TL - 1, TL - 2.
- Six different power consumers (Up to 10 MW) – Gen.Industry, Emergency, Urban Area, Rural Area, Cement, Chemical Industry.
- Six analog pot-meters for the power consumption control.
- Graphics LCD & Keypad based configuration & monitoring of smart grid.
- On board LCD & PC based GUI for easy understanding of the smart grid operation.
- Automatic Smart Grid Control algorithm implemented for transmission line control, over current relay & automatic load sharing/adjustment in case of over loading.

Units	Capacity	Qty.	Details
Generating Station (Simulated)	**5MW (TOTAL) (Programmable)**	**6**	**Wind, Solar, Diesel, Bio-Gas Fuel-Cell, Utility Grid**
Transmission Line Simulated	**2.5MW EACH (Programmable)**	**2**	**TXN Line-1, TXN Line - 2**
Power Consumer Simulated	**5MW (TOTAL) (Programmable)**	**6**	**Gen.Industry, Emergency, Urban Area, Rural Area, Cement, Chemical Industry**
Energy Meters Simulated	**- -**	**6 + 6**	**Generating + Consumption Uni-directional - 11 + Bi-directional - 1**
Monitoring & Control	**- -**	**1 + 1**	**Graphics LCD, Keypad & PC**
Interface	**- -**	**1**	**USB2.0 based PC Interface/MODBUS/Ethernet**

Experiments on SMART GRID

1. Smart Grid Simulator Basic Architecture & Operation study and analysis.
2. Study of different Generating Stations, Utility Grid, Sub-Stations, Transmission Line, Distribution Station and different Consumers in SMART-GRID.
3. Study of Energy Meter Network, Power flow Monitoring & Control over generating stations, transmission lines, distributing stations & different power consumers.
4. Study of Transmission Line Overload/fault generation & correction and its automatic Bypass Operation.
5. Study of Automatic Load balancing & Priority based Consumer Power Shut-Down.
6. Study of Advanced Monitoring & Control used in SMART-GRID.
7. Study of Monitoring smart grid on Visual Basic Screen in PC
8. Study of PLC S7_1200 based Monitoring Smart grid on SCADA screen & MATLAB screen in PC

VIII) Components for Building 10/25KW Smart Grid Power Generation

i)10KW IGBT Based Power Module

ii) 25KW Power Module for Multilevel Inverter

Specification

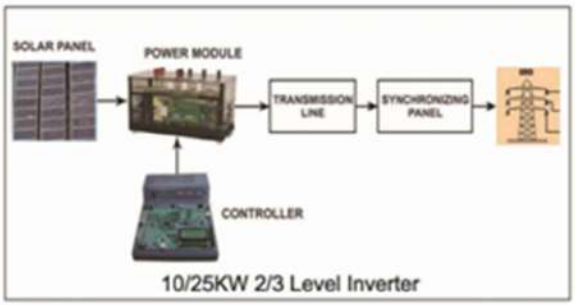
* 1200V/ 75A, Peak Semikron based IGBT module
* 8 Nos of IGBT's provided with independent eight driver (inbuild opto isolator)
* All the collector and emitter terminals are brought out in proper connector for power circuit connection
* All the gate and emitter terminals are brought out and terminated on front panel to view driver output fault output
* Indicator LED provided for PWM input and power supply input
* Proper heat sink provided for all the IGBTs with cooling fan provision
* All are enclosed by viewable acrylic cabinet
* Temperature sensor provided for over temperature Protection
* PWM inputs are brought out on Front Panel, you may connect any controller for interface
* One common +15V Power supply for all the driver circuit, Inbuilt isolated power supply provided.
* Over current protection and short circuit protection provided for all individual IGBT module
* Reset circuit provided and terminated to clear the fault
* Snubber capacitor provided for dv/dt protection for all IGBT module
* 60A 3 phase bridge rectifier and filter circuit available for power circuit input.

3 phase 3 level MLI Specification

* 600V/200A Peak MLI IGBT based power module
* 4nos of IGBT with 2nos of diode module in single pack
* 12nos of independent HLPC 316J based opto isolated IGBT driver
* 1no of 150A bridge rectifier provided for power circuit input and 1600±50µF capacitor [3300uF/450V x 2 capacitors in series in DC link (Ph-LL9 long life grade)] provided for filter circuit.
* Snubber capacitor provided (0.6uF/1000VDC/Ref.IEC61071 in each leg) for dv/dt protection
* Heat sink for all IGBTs with cooling fan provision.
* Sandwiched platted DC link structure
* Powerex based isolated DC-DC converter for driver power supply (VLA106-15242)
* Separate externally Power supply for all the driver circuit is derived from 230V AC - 15V DC.
* 4 hall effect current sensor (50A) with signal conditioner for sensing the DC link current and each output phase current.
* Over temperature protection @ 75°C
* Device short circuit protection for all the IGBT module
* PWM interlock protection for each phase
* Over current protection for each phase and DC link current Indicator LED proved for Fault outputs/power supply input and PWM inputs.
* PWM inputs are brought out on front panel for external controller and Dspace interface.
* Reset circuit with LED indication provided and terminated to clear the fault.
* All are enclosed in transparent acrylic sheets with power terminals (Three terminals of DC bus, 3 phase input and 3 phase output) available for connection with standard high power rated banana connectors.

Suggested Controllers

1. TMS320F2812 based DSP controller (Micro-2812)
2. TMS320F28335 based DSP controller (Micro-28335)
3. Piccolo based DSP Controller (Micro-28069)
4. dsPIC 30F6015 based controller (Micro-6015)
5. dsPIC 33EP814 based controller (VPE-33EP)
6. Spartan 3A Based FPGA controller (VPE-Spartan 3A DSP)
7. Spartan 6 Based FPGA Controller (VPE-Spartan 6)
8. AD-Spartan 6 FPGA Based Controller (VPE - SP6AD)
9. Cyclone IV Based FPGA controller (VPE-CYIV)
10. Cyclone V FPGA Development Board (DE1-SoC)
11. AD-CortexM4 Based Embedded-DSP Controller (VPE-Ad m4)
12. ST-Cortex-M4 Based Embedded-DSP Controller (VPE-St m4)



10/25KW 2/3 Level Inverter

IX) i) IoT Based Wireless Data Acquisition

It consists of IoT 2040 Gateway to connect to Siemens SCADA or DCS Software PCS7 or to a cloud server through WiFi.

* It can interface RS485 with modbus of various modules of Smart Grid.
* With WiFi add on module, IoT 2040 can also interface with Internet for cloud based application.
* Open platform for collecting, processing and transferring data directly during operation.
* It transfers Data from the Smart Grid unit to the cloud and vice versa.
* With varied communication protocols and HLL programming allows Tailored Solutions.
* IoT 2040 can easily be integrated into the existing plant, SCADA, PCS7.

ii) i5 - 6 Core Cloud Server

* i5- 8th Generation, 6 core @ 2.8 GHz
* 16GB RAM
* 2 TB Hard Disk
* Mouse and Keyboard
* Open Source Virtualization Software

X) Other Add Ons

ii) Fuel Cell

* Fuel cell - 200W x 5 Nos
* Total Power - 1000W
* Rated Power/Cell - 200W
* Rated Performance/Cell - 24V/8.3A
* Low Voltage Protection - 20V
* Over Current Protectiom - 12A
* Over temperature Protection - 65°C
* 5Nos connected in series

1KW DC-DC Buck - Boost Converter for Fuel Cell

* Microcontroller based Buck - Boost with MPPT algorithm
* Switching device IGBT/ MOSFET
* I/P voltage range : 120V -210V DC
* O/P voltage range : 380V DC / 3A
* All the I/P & O/P are sensed through isolated sensors
* 4Nos of ADC feedback provided to sense
  - I/P Voltage of Solar, I/P Current of fuel cell
  - O/P Voltage & Current of Converter
* 4 keys provided to select the type of control program
* Banana connector termination provided for input & output with MCB protection.
* 20x4 LCD displays all the I/P / O/P data
* Over current, over voltage & temperature protection.
* dv/dt protection is available for IGBT (Snubber Circuit)
* One RS232/RS485 port provided to Interface with PC/PLC

iii) Super Capacitor

* Rated Capacitance per super capacitor - 500F
* Test Current for Capacitance and ESR DC - 100A
* Maximum Voltage - 17V
* Rated Voltage - 16.2V
* Total Voltage : 162V DC Max.
* 16V working Voltage
* Resistive or active cell balancing available
* 10Nos connected in series

Bi-Directional Buck-Boost Converter for Super Capacitor

* Microcontroller based DC - DC Controller
* 2 Nos of High Speed MOSFET/IGBT
* 2 Nos of Isolated High Speed Driver circuits
* 2 Nos of Current Sensor for sensing the input and output current of the converter
* 2 Nos of Voltage Sensor for sensing the input and output voltage of the converter
* In Boost mode I/P is 162V DC and O/P is 380V DC
* In Buck mode I/P is 380V and O/P is 162V DC
* Power Rating is 1000 Watts
* dv/dt protection is available for all IGBT (Snubber Circuit)
* 20x4 Alpha Numeric LCD display
* One USB/RS485 provided to Interface PC or PLC
* Test points provided in control section for wave form measurement in CRO

iv) Load Controller

* Microcontroller dsPIC4011 based load controller
* Load can be controlled through RS485 input
* Five no of relays used to switch ON/OFF load, depends on input from MODBUS.
* 20x4 LCD displays the current status of load.
* Input and output terminals provided in the front/back panels
* This will work with resistive load.

v) Battery Charger

* Power factor controlled battery charger
* Input 230V AC
* Output voltage 96V DC
* Output current 12A DC