GOVERNMENT COLLEGE OF TECHNOLOGY,COIMBATORE-13

TEQIP PHASE –II
CENTER OF EXCELLENCE ON
ALTERNATE ENERGY RESEARCH

DEPARTMENT OF ELECTRICAL AND
ELECTRONICS ENGINEERING

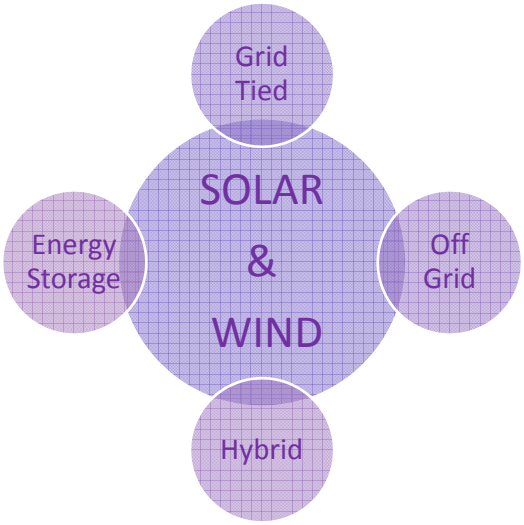
CENTRE FOR ALTERNATE ENERGY RESEARCH

Principal Investigator :Dr.N.DEVARAJAN
Professor of Electrical Engg.
Co-Investigator :Prof K.YASODA
Asst. Professor in Electrical Engg.

Areas of Excellence

WIND POWER AND SOLAR ENERGY

RESEARCH ACTIVITIES



i) Thematic Areas of Research:

- Solar Energy
  - i) Stand alone Photovoltaic(PV)systems with energy storage
  - ii) Grid connected solar PV system
- Wind Energy
  - Grid connected wind energy systems with different types of aero generators.

Specific Objectives of CoE

- **Maximum Power Point Tracking (MPPT) for (i) Solar power system under varying light and load conditions (ii) Fixed and Variable speed Wind power system**
  - Obtaining the optimum operating point for maximum power delivery for all possible radiation levels and wind speeds.
  - The main goal of the MPP tracker is to operate solar panels and wind turbine generators at the optimal operating point.

Specific Objectives of CoE(Contd.)

- **Design and development of converter systems with intelligent controllers for**

  - Efficiency Improvement in energy conversion systems

  - Meeting or exceeding the power quality as specified by the International standards.

Specific Objectives of CoE(Contd.)

- **Modeling and simulation of solar PV /Wind Generating systems to study the impact of solar and wind power penetration on the grid.**

  - Software - MATLAB, PSIM, DigSILENT

  - Solar/Wind energy systems under grid faults (Fault Ride Through)

Specific Objectives of CoE (Contd.)

- **Identification of reliable and effective energy storage technologies for solar and wind energy Systems**

  - Energy storage using Super capacitors and Batteries

Procurement(Completed)

Sl.No.	Equipments	Cost(Rs. in Lakhs)
1	Solar Grid Tied training System	4
2	Solar PV Emulators	6.25
3	Power Quality analyzer	8.5
4	Digital Storage Oscilloscopes (2 Channel)	2.3
5	Isolated 4 Channel digital Oscilloscope	6
6	Metering instruments	4
7	USB -DAQ	2
8	Dig SILENT software	2.2
9	PSIM software	9.85
10	Loading setup	5
11	Personal Computers	9.59

Procurement (Purchase order issued)

Sl.No.	Equipment	Cost(Rs.in Lakhs)
1	5 kW solar PV panels	9.9
2	Weather Monitoring Station	8
3	DFIG wind turbine Experimental Set Up and Accessories	9.9
4	Regulated power supplies	1
5	Wind Turbine Emulator	6
6	MATLAB Software	20

Procurement (to be initiated)

Sl.No.	Equipments	Cost(Rs .in Lakhs))
1	PMSG based wind turbine setup and accessories	5
2	Energy storage system and accessories	9
3	FACTS controllers and accessories	5
4	DSPACE	17
5	LCR Meter	1.2
6	IR Thermometer	6
7	E –Journals, Books	1.98

500 W solar Panel

Loading Set up

Grid Tied Solar System/Solar PV System

Computing Facility-MATLAB,PSIM & Dig SILENT

Digital Storage Oscilloscope(Two Channel)

Digital Storage Oscilloscope(Isolated four channel)

Data Acquisition Module

Power Quality Analyzer

i)Research Projects initiated under CoE

Title of the Project

Maximum Power Point Tracking of PV Array Using Short Circuit And Open Circuit Values For A Single–Stage Grid Connected Inverter

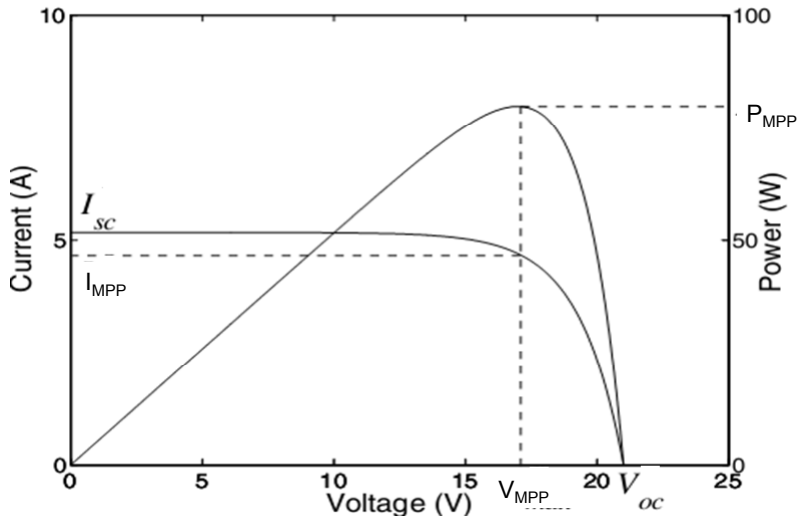
Objective

Design and develop a single stage power interface for photovoltaic (PV) panel to the grid with a novel non-iterative Maximum Power Point Tracking (MPPT) method using a current controlled voltage source inverter.

Methodology

- This research project uses the short circuit current (I_{sc}) and the open circuit voltage (V_{oc}) of the PV module to obtain the power at maximum power point(MPP).
- In solar PV modules, the ratio between current at MPP (I_{MPP}) and the short circuit current (I_{sc}) as well as the voltage at MPP(V_{MPP}) and open circuit voltage (V_{oc}) are constant under any irradiance conditions.
- This feature of the PV module is utilized to obtain the maximum power (P_{MPP}) and subsequently used in the inverter control.

I-V CHARACTERISTICS OF A PV PANEL



Methodology (contd.)

- Two control switches are used in the power circuit for periodic opening and shorting of the PV panels during operation, so as to obtain the I_{sc} and V_{oc} of the PV panel.
- The obtained P_{MPP} is used to calculate the reference current with the help of line to line voltages at the point of common coupling.
- Sinusoidal band Hysteresis current controller is used for generating gate pulses for inverter

Proposed MPPT Algorithm

- MPP current (I_{mpp}) and short circuit current(I_{sc}) of the panel are related by a constant

$$I_{mpp} = k_i I_{sc}$$

under any irradiance conditions

- Similarly MPP voltage(V_{mpp}) and open circuit voltage(V_{oc}) of the panel are related by a constant

$$V_{mpp} = k_v V_{oc}$$

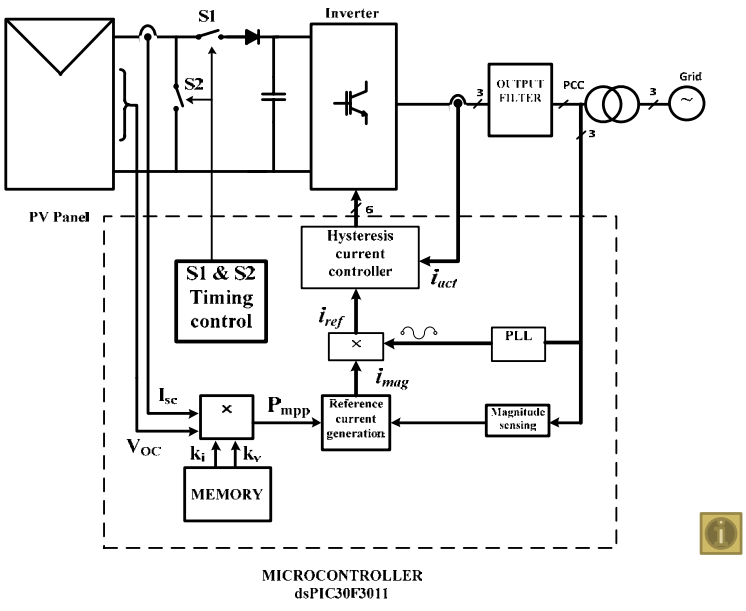
under any irradiance conditions

- Hence the MPPT can be achieved by measuring V_{oc} and I_{sc} of the panel at any instant

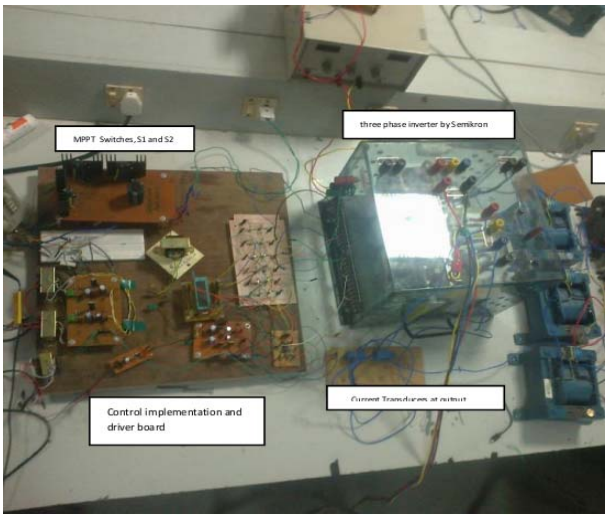
Proposed MPPT Algorithm(contd.)

- The described technique can be used to obtain the optimum operating points of the PV panel.
- Hence the MPP power of the panel can be calculated as $P_{mpp} = (V_{oc}k_v)(I_{sc}k_i)$
- The proposed algorithm calculates the power from the periodically sensed values of V_{oc} &I_{sc}
- The estimated P_{mpp} will serve as the reference power for the inverter controller

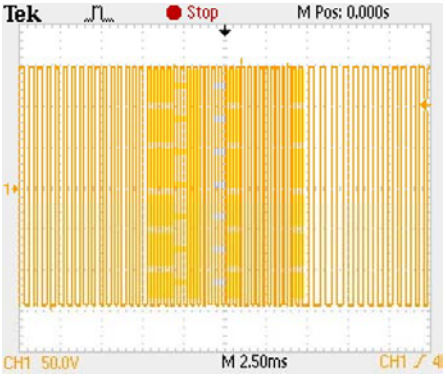
CLOSED LOOP CONTROL OF THE SINGLE STAGE INVERTER WITH THE PROPOSED MPPT



The experimental set-up of the proposed MPPT for grid connected single stage inverter

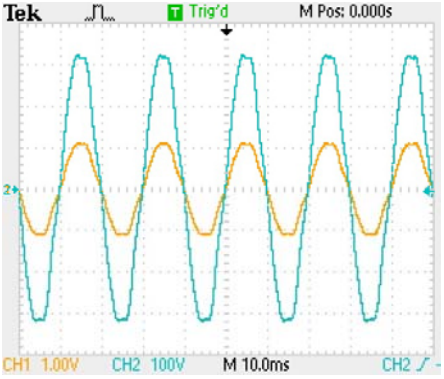


Experimental Results



Inverter output voltage

P_{MPP} found @ the dc side = 489.5W
Corresponding ac side current = 1 A (Pk)



Voltage and current at PCC for 1100 W/m^2

Conclusions and Future Directions

- The complete hardware setup of the proposed system is implemented.
- The gate pulses to the shunt and series switches for MPPT were generated with dsPIC controller.
- The closed loop hysteresis current control strategy was tested in the hardware circuit.
- Oscillations around the optimum operating point is not felt.
- The power values found by the proposed MPPT algorithm are verified through load tests and compliance confirmed.

Research Publications

- Vijayakumari.A, N.Devarajan, 'Design and development of a model based hardware simulator for photovoltaic array', Elsevier International Journal of Electrical Power & Energy Systems, Vol.43, no.1 Dec.pp.40-44, 2012.

- Vijayakumari.A, N.Devarajan, 'Maximum Power point Tracking of PV array using short circuit and open circuit values for a single- stage three phase grid connected inverter', Elsevier International Journal of Renewable Energy,2013, **Communicated**

Other Research Projects initiated under CoE

Title of the Projects

- Adaptive Maximum Power Point control Algorithm for Small Scale Wind turbines
- Doubly Fed Induction Generator Experimental Set Up

ii)Training and Pedagogy

- New Courses-Electives offered-UG and PG
- Faculty Development Programs/ Workshops/Seminars- Attended and Organized

Core/Electives subjects-B.E-EEE

- Renewable Energy Sources (Core)

  Need for alternative energy-basics of wind , solar, ocean, biomass and geothermal energy

- Smart Grid Technology

  Role Instrumentation and Information Technology in power systems-Enhancing the performance of Existing system

- Energy storage technology

  Types of Energy storage systems-methodology-applications(Quantitative treatment)

Core /Electives Subjects-M.E-Power Electronics and Drives/Power Systems Engineering

- Wind Energy Conversion Systems

  Aero generators-Types and control-Grid connected/off grid operation-role of power electronics in Wind energy

- Power Electronics In Wind and Solar power Conversion

  Feasible power electronic converter topologies-Power Quality improvement

Core /Electives Subjects-M.E-Power Electronics and Drives/Power Systems Engineering

- **Smart Grid Technology and its Applications**

  Role Instrumentation and Information Technology in power systems-Enhancing the performance of Existing system

- **Advanced Energy Storage Technology**

  Types of Energy storage systems-methodology -applications (Qualitative treatment)

FACULTY DEVELOPMENT PROGRAMMES /SHORT TERM COURSES-ATTENDED

Sl. No.	Name of faculty Members	Title of the FDP/Workshop or Purpose of visit	Place/Period
I	Dr.N.Narmadhai Dr.R.Rajeswari Dr.P.Maruthupandi	STC on "Simulation of Power Electronic Circuits"	Indian Institute of Technology, Bombay (Center for Photovoltaic research) 08.1.2013-09.10.2013
2	Dr.V.Geetha Dr.E.LathaMercy Prof.K.Yasoda	STC on Smart Grid-Technology and Applications	Center Power Research Institute, Bengaluru. 25.11.13-29.11.13
3	Dr.V.Prasanna Moorthy	Seminar on HYPERSIM and EMEGAsim	OPAL-RT Technologies, India 04.12.2013
4	Dr.V.PrasannaMoorthy Dr.K.Ranjit Kumar	National workshop on Institutional Development and Quality Management	Hotel Le Royal Meridien,Chennai 11.12.13-13.12.13

FACULTY DEVELOPMENT PROGRAMMES /SHORT TERM COURSES-ATTENDED

Sl.No.	Name of faculty Members	Title of the FDP/Workshop or Purpose of visit	Period
5	Dr.N.Devarajan Dr.R.Rajeswari	Innovative Teaching, Research , Learning and Accreditation Practices	Hotel Leela palace, Chennai 20.12.13 -22.12.13
6	Dr.P.Maruthupandi	CII-SR Education Excellence Forum	DOTE-Chennai 20.12.13
7	Dr.P.Maruthupandi	Workshop on Accreditation and Autonomy	ISTE-WPLP Kanyakumari 06.01.14-08.01.14
8	Prof.S.Chitra	Engineering Pedagogical Techniques	Bengaluru 20.01.14-24.01.14
9	Prof.K.Yasoda	Research Methodology –The science of creating new knowledge	The Residency Towers,Chennai 27.01.14 -29.01.14
10	Dr.V.Geetha	Academic Leadership programme	Indian Institute of Management,Trichy 10.02.14-14.02.14

FACULTY DEVELOPMENT PROGRAMMES /SHORT TERM COURSES-ATTENDED

Sl.No.	Name of faculty Members	Title of the FDP/Workshop or Purpose of visit	Period
11	Dr.V.Prasanna Moorthy	Internationalization of Higher Education	Radisson Blue Hotel, Jaipur 20.03.14-22.03.14
12	Dr.P.Maruthupandi Dr.R.Rajeswari	Workshop on Structural Dynamics	Indian Institute of Technology, Delhi 22.03.14
13	Dr. V. Geetha Dr. V. Prasanna Moorthy	Workshop on Personal Leadership for senior Faculty	The Coimbatore Productivity council , Conoor 04.04.14 - 06.04.14
14	Prof. K. Yasoda	Short term Course on Control of Permanent Magnet AC Machines	Indian Institute of Technology, Chennai 03.04.2014 -05.04.2014
15	Dr. K. Ranjithkumar	Workshop on Advance in Solar Energy & Utilization – Fast Forward solar Missions	Anna University, Chennai 07.04.2014 - 08.04.2014

RESEARCH LABORATORY VISITS

Sl.No.	Name of faculty Members	Purpose of visit	Place/Date
1	Dr.N.Devarajan Prof.K.Yasoda Dr.P.Maruthupandi	Solar thermal and solar photovoltaic lab	Indian Institute of Technology, Madras. 20.08.2013
2	Dr.N.Devarajan Prof.K.Yasoda Dr.N.Narmadhai	Center for Energy Studies	Anna University, Chennai. 30.08.2013
3	Dr.N.Devarajan Dr.N.Narmadhai Dr.R.Rajeswari Dr.P.Maruthupandi	Center for Photovoltaic research	Indian Institute of Technology, Bombay. 10.10.2013
4	Dr.V.Geetha Dr.N.Narmadhai Dr.E.LathaMercy	100kW-Solar Power Plant	Aerospace Pvt.Ltd Pollachi. 31.10.2013

WORKSHOPS/SEMINARS-ORGANIZED

Sl.No.	Title of the Seminar/Workshop	Date
1	Seminar/Demonstration - Dig SILENT –Power Factory Software	21.02.14
2	Seminar/Demonstration - USB-DAQ using Lab VIEW Software	25.02.14
3	Workshop on “Overview of Wind and Solar Energy Systems”	13.03.14
4	Seminar/Demonstration – MATLAB Software	27.03.14

WORKSHOPS/SEMINARS-ORGANIZED

Sl.No.	Title of the Seminar/Workshop	Date
5	Seminar/Demonstration - PSIM Software	28.03.14
6	Seminar/Demonstration – Solar Grid Tied Module and Solar PV Emulator	01.04.14
7	Seminar/Demonstration –Application of NI technology in the field of Alternate Energy Resources	02.04.14

COLLABORATION WITH INDUSTRIES AND INSTITUTIONS –UNDER PROCESS

- Consortium of Institutions between Anna University, Chennai and Government College of Technology, Coimbatore.
- Initiation of Memorandum of Understanding Gamesa Wind Turbines Pvt.Ltd,Chennai .
- MoU with Coimbatore Solar Energy Solutions and Alpha Power (P) Ltd, Coimbatore.
- MoU with Asian Institute of Technology, Thailand.

Thank You!

Reference current estimation

Power at dc side= Power at ac side

$$P_{mpp} = V_{mpp} I_{mpp} = \sqrt{3} v_{LL} i_{LL} \cos\varphi$$
$$P_{mpp} = k_i k_v V_{oc} I_{SC}$$

Where,

v_{LL} is the Line to line voltage of the grid

i_{LL} is the rms current to be delivered for extracting maximum power.

The magnitude of the reference current is estimated as,

$$\hat{i}_{ll} = \frac{P_{mpp}}{v_{LL}} \left(\frac{\sqrt{2}}{\sqrt{3}} \right)$$

$$i_{ref} = I_m \sin \omega t$$ Sine ωt is obtained from PLL

The upper and lower hysteresis band values with 5% band (H) are calculated as,

$$i_{up} = (i_{ref} + H) \sin \omega t \qquad i_{low} = (i_{ref} - H) \sin \omega t$$

The reference currents are compared with actual currents to generate gating pulses for inverter using Hysteresis current controller