Curriculum Vitae of Dr. Saurav Pramanik

I. General

Name	Saurav Pramanik
Permanent Address	Saurav Pramanik C/O: Prasanta Pramanik Vill: Suranankar, P.O.: Panskura R.S. Dist: Purba Medininpur, WB, INDIA PIN: 721152
Address for Communication	Room No: N 234 EE Dept., IIT Kharagpur Kharagpur, India 721302
Email	saurav.pramanik@gmail.com
Office Tel:	+91-3222 283076
Date of Birth	26-09-1984
Category	General

II. Academic qualification

Degree	Year	University	Thesis/Course
Ph.D.	July 2010-Nov. 2013	I.I.Sc Bangalore Dept. of EE	Title: "Frequency and Time Domain Response Analysis of Transformer Winding for Indirect Measurement of Series Capacitance and Construction of Ladder Network Models"
M.Sc (Engg.)	Aug. 2008-June 2010	I.I.Sc Bangalore Dept. of EE	Title: "Complex Network-Function-Loci for Localization of Discrete Change in Transformer Windings"
B.E.	July 2002-June 2006	Jadavpur University, Kolkata Dept. of EE	Course: Electrical Engineering

III. Postdoc in Corporate Research, ABB, Västerås, Sweden

Position: Scientist
Tenure: 21 Months (April 2014 – January 2016)

IV. Publication Record

1	IEEE Transactions on Power Delivery	**4 + 1* +1****
2	IET Electric Power Applications	**2**
3	Electric Power Systems Research	**1**
4	International Conferences	**3**
5	International Reports + ABB's Internal Technical Reports	**3 + 2**
	Total	**17**

** A correction paper ** Manuscript under preparation*

V. Awards and Fellowships[+]

- Conferred "**Young Researcher Award**" for outstanding scientific research and excellent presentation in **18th International Symposium on High Voltage Engineering**, Seoul, Korea, August 25-30, 2013. Award carries a citation and cash prize of USD 500/-.
- Conferred "**POSOCO Power System Award (PPSA-2014)**" **for doctoral thesis work** (recommended as the best thesis). This award is presented by Power System Operation Corporation Limited in partnership with Foundation for Innovation and Technology Transfer, IIT Delhi. Award carries a citation and cash prize of INR 60,000/-.
- Conferred **"Prof. D J Badkas Medal"** for best PhD thesis in the **Department of Electrical Engineering, IISc.** Bangalore for the year 2015-2016
- Awarded Graduate Fellowship from Ministry of Human Resource Development, Govt. of India, since August 2008 to April 2014, spanning M.Sc. and Ph.D. degrees.

[+] *Certificates are enclosed in the end*

VI. List of Publications

In Refereed International Journals

Published

1. **Saurav Pramanik** "Resonance Behavior and Sensitivity to detect Mechanical Change in Transformer Winding: Shunt Current versus Neutral Current", **IEEE Trans on Power Delivery,** Vol. 30, No. 5, Oct. **2015**, pp. 2276-2283**.**
2. **Saurav Pramanik** and L. Satish, "A Critical Review of the Definition of FRA Resonance Frequency of Transformers as per IEEE Std C57.149-2012", **Electric Power Systems Research,** Vol. 121, **2015**, pp. 52-57.

3 **Saurav Pramanik** and L. Satish, "Time-Domain Approach to estimate series capacitance of an Isolated Phase Winding of a Transformer", **IEEE Trans on Power Delivery,** Vol. 29, No. 4, Aug. **2014**, pp. 1939-1945.

4 **Saurav Pramanik** and L. Satish, "Estimation of Series Capacitance for a Three-Phase Transformer Winding From Its Measured Frequency Response", **IEEE Trans on Power Delivery,** Vol. 28, No. 4, Oct. **2013**, pp. 2437-2444.

5 **Saurav Pramanik**, Sana Anees and L. Satish, "Interleaved Winding and Suppression of Natural Frequencies", **IET Electric Power Applications,** Vol. 7, Issue 4, April **2013,** pp. 237-244.

6 **Saurav Pramanik** and L. Satish, "Estimation of Series Capacitance of a Transformer Winding Based on Frequency-Response Data: An Indirect Measurement Approach", **IEEE Trans on Power Delivery**, Vol. 26, No. 4, Oct **2011**, pp. 2870-2878.

7 **Saurav Pramanik** and L. Satish, "Localization of Discrete Change in a Transformer Winding: A Network-Function-Loci Approach", **IET Electric Power Applications,** Vol. 5, Issue 6, **2011**, pp. 540-548.

CORRECTION

8 **Saurav Pramanik** and L. Satish, Correction to "Estimation of Series Capacitance of a Transformer Winding Based on Frequency-Response Data: An Indirect Measurement Approach", **IEEE Trans on Power Delivery**, Vol. 29, No. 1, Feb **2014**, pp. 302-303.

MANUSCRIPT UNDER PREPARATION

9 **Saurav Pramanik** and Subrat Sahoo, "Tank Current Measurement in 3-Phase Transformer: Its Resonance Behavior and Sensitivity to Detect Mechanical Faults", ***manuscript is under preparation for submission to IEEE Trans on Power Delivery.***

International Conferences

10 **Saurav Pramanik** and L. Satish, "Enhancing Physical Resolution of Constructed Ladder Network for an Interleaved winding", IEEE 1st International Conference on Condition Assessment Techniques in Electrical Systems, **IEEE CATCON 2013**, Kolkata, India, Dec. **2013**, pp. 60-65.

11 **Saurav Pramanik** and L. Satish, "Estimating Series Capacitance from Measured FRA-Single Isolated and 3-Φ Transformer Winding results", **18th International Symposium on High Voltage Engineering 2013**, Seoul, Korea, Aug. **2013**, OF2-05, pp. 1782-1787.

12 **Saurav Pramanik** and L. Satish, "Physical Representation of a Transformer Winding by a Coupled Ladder Network Constructed From its Measured Frequency Response", **18th International Symposium on High Voltage Engineering 2013**, Seoul, Korea, Aug. **2013**, PF-39, pp. 2130-2135.

ABB's Internal Technical Reports

13 **Saurav Pramanik** and Co-Authors in ABB: Technical Report on "Stray flux control and reduction of stray losses: A new design of transformer winding." TR2013-PT/401, pp. 1-37.

14 **Saurav Pramanik** and Co-Authors in ABB: Technical Report on "An innovative use of amorphous material in transformer core to reduce the core losses: A novel design of transformer core", report is under preparation.

International Reports

15 L. Satish and **Saurav Pramanik**, Technical Advice on "Fundamental understanding of the resonance behaviour of inductively coupled ladder network circuits", submitted to **Doble Engineering Company**, USA, March **2011**, pp. 1-6.

16 L. Satish and **Saurav Pramanik**, Technical Report on "An Attempt to Offer Physical Insight to Explain Changes in Frequency Response Corresponding to Changes in Non-tested Winding Interconnections," submitted to **Doble Engineering Company**, USA, Sept **2012**, pp.1-10.

17 L. Satish and **Saurav Pramanik**, Technical Advice to Prof. Ryszard Malewski (Consultant), Montreal, Quebec, Canada, on "Behavioural aspects of mutually coupled ladder networks with respect to transadmittance modulus and phase frequency characteristic to interpret frequency response measurements taken on a large transformer that failed the test," August **2008**, pp. 1-9.

VII. Reviewing Activity

International Journals

1. IEEE Trans. on Power Delivery
2. IEEE Trans. on Industrial Electronics
3. IET Electric Power Applications

VIII. Research Guidance

- Guidance at Masters Level (co-guide): 1 (in progress)
- Guidance at Summer Intern Level: 1 (completed)

Supervised and guided one summer student at Corporate Research, ABB in Västerås, Sweden for a duration spanning from June' 2015 to August' 2015. The work was related with the IP review study for landscaping the recent advances in transformer technology.

IX. Research Experience in IISc (M.Sc. and Ph.D)

- Experience in transformer diagnostics using FRA measurement for
  - ✓ Estimating winding series capacitance and construction of ladder network model
  - ✓ Localization of winding deformation and fault analysis
  - ✓ Modeling of frequency dependency of inductances in a coupled ladder network
  - ✓ Enhancing physical resolution of ladder network model for transformer winding
- Interleaved winding and its effect in suppressing the natural frequencies
- Time-domain response analysis to estimate the series capacitance of a transformer winding
- A critical review of the definition of FRA resonance frequency of transformers as per IEEE Std C57.149-2012 and provide appropriate material for its correction

X. Research Experience in Corporate Research, ABB (postdoc)

Team Work

- ✓ An innovative use of amorphous material in transformer core to reduce core losses
- ✓ Stray flux control and reduction of stray losses: A new design of transformer winding
- ✓ Feasibility study of a new concept for surge protection of power transformer

Individual Work

- ✓ Resonance Behavior and Sensitivity to detect Mechanical Change in Transformer Winding: Shunt Current versus Neutral Current
- ✓ Tank Current Measurement in 3-Phase Transformer: Its Resonance Behavior and Sensitivity to Detect Mechanical Faults
- ✓ Dielectric spectroscopy in time and frequency domain for oil-paper transformers: A preliminary work to characterize the measured response and construct an equivalent model to assess the insulation condition

STP Proposal

- ✓ Proposed two new potential research ideas to contribute to the strategic technology plan (STP) for the year of 2015

XI. Research Interest and Future Work Plan

- Dielectric spectroscopy in time and frequency domain for oil-paper transformers
- Construction of an equivalent model from the measured dielectric response of an oil-paper transformer to assess the insulation condition
- Explore new high voltage testing and measurement techniques
- Frequency response analysis of transformer winding

- Modeling of HV power apparatus to study its dynamics
- Impulse behavior analysis and surge protection of power transformers
- Partial discharge testing and measurement on transformer
- PD as a diagnostic tool and non-conventional PD measurement techniques
- Detection, recognition and localization of PDs in power apparatus

XII. Research Highlights and Contributions

Research topics pursued by the supplicant over the past seven years are in the broad area of diagnostics and condition monitoring of high voltage power transformers. Specifically, the following is a highlight of the major contributions-

1. Establishment of an indirect method to measure the series capacitance of a single, isolated transformer winding based on frequency response data
2. Extraction of series capacitance of a 3-phase transformer from its composite frequency response
3. Estimation of series capacitance from time-domain response analysis
4. Physical representation of a transformer winding by a coupled ladder network constructed from its measured frequency response
5. Enhancing Physical Resolution of Constructed Ladder Network for an Interleaved winding
6. Effectiveness of interleaved winding in suppressing natural frequencies- Experimental study and establishment of an analytical basis
7. A critical review of the definition of FRA resonance frequency of transformers as per IEEE Std C57.149-2012 and provide appropriate material for its correction
8. Tank current resonance behavior and its sensitivity to detect mechanical changes in transformer winding: A new diagnostic approach
9. Network-Function-Loci for localization of discrete change in a transformer winding
10. Simulation of static frequency converter using thyristor for use in induction furnace (B.E. Project)

(*A brief summary of these contributions is included in the end*)

XIII. Industrial Job Experience: (July'2006- July'2008)

Two years of industrial experience in electrical projects at-

- Vedanta Alumina Refinery Project, Lanjigarh, Orissa, India
- 'H' Blast furnace project in Tata Steel, Jamshedpur, India
- Vedanta Aluminum Plant, Jharsuguda, Orissa, India

Nature of work involved Erection, Testing and Commissioning of electrical apparatus like Transformers, Switchgear Panels, Power and Control Panels, Induction Motors, Megger and DC HI-POT test of HV cable, Relay and Protection scheme checking. Testing of Switchgear Panels includes testing of CT, PT, Circuit Breaker (both LV and HV).

XIV. Computational Skills

- Fluent in use of MatLab, Maple and PSPICE
- Conversant in the use of C and Fortran 90

XV. Special Achievement

Selected as a Junior Scientific Officer in Bhaba Atomic Research Centre (BARC, an Indian Central Govt. Research Centre) in July, 2008, Mumbai, India

XVI. Conference/Workshop Attended

- Attended the "Lightning" Workshop in IISc, Bangalore, India, Dec. 8th and 9th in 2009
- Attended 18th International Symposium on High Voltage Engineering at Seoul, Korea, August 25-30, 2013.
- Attended 1st IEEE International Conference on Condition Assessment Techniques in Electrical Systems, IEEE CATCON 2013, Kolkata, India, Dec. **2013**.

I hereby declare that all the above information furnished herein is true to my knowledge and belief.

Date: 30 June 2016 Signature
Place: Kharagpur, India

XVII. Summary of Research Highlights

1. Estimation of series capacitance for a single isolated winding based on frequency response data

   It is based on converting the measured driving-point-impedance (DPI) magnitude response into a rational

function and thereafter exploiting the ratio of a specific coefficient in the numerator and denominator polynomial, which leads to the direct estimation of series capacitance. The theoretical formulations were derived for a mutually coupled ladder-network model, followed by sample calculations. The results obtained are accurate and its feasibility was demonstrated by experiments on model-coil and on two actual, single, isolated transformer windings viz. interleaved and continuous-disk winding. It is believed that the proposed method is the closest one can get to indirectly measuring series capacitance.

2. Estimation of series capacitance for a 3-phase transformer from its measured frequency response

The fundamental principle proposed in the earlier work was appropriately modified and experimental results on a 3-phase transformer (4 MVA, 33kV/433V) were presented along with results on the winding considered in isolation (for cross validation). Later, the method was directly implemented on another 3-phase unit (3.5 MVA, 13.8kV/765V) to show repeatability. It emerged from the results that the method is robust and accurate for 3-Φ winding. Furthermore, establishing the fact that the core and neighbor windings cause negligible influence to the estimated series capacitance (although in a limited way) was the important contribution. Thus, the successful implementation of the proposed method for both single isolated and 3-Φ winding paves the way to achieve the ultimate goal such as-

- Connect an FRA instrument to the HV winding of a 3-phase transformer unit
- Measure FRA in the usual way, and, after some calculations,
- Display the series capacitance (Cs) value of the tested HV winding!

It is believed that the proposed method would definitely interest the industry, transformer manufacturers, and also the FRA instrument companies.

3. Time-Domain approach to estimate the series capacitance of a transformer winding

The idea was developed based on the well-known fact that under impulse excitation, the line/neutral current in a transformer has three distinct components, of which, the initial capacitive component is the first to manifest, followed by the oscillatory and inductive components. Of these, the capacitive component is temporally well-separated from the rest; a crucial feature permitting its direct access and analysis. Further, the winding initially behaves as a pure capacitive network, so, the initial component must obviously originate from only (the series and shunt) capacitances. Going by this logic, it was possible to estimate Cs, just by measuring the initial capacitive component. The principle of the method and details of its implementation on the same two earlier windings (interleaved and continuous-disk) were reported. For implementation, a low voltage impulse generator, a current probe and a digital oscilloscope is all that is needed. The method is simple, requires no programming, and involves least user intervention, thus, paving way for its automation.

4. A critical review of the definition of FRA resonance frequency of transformers as per IEEE Std C57.149-2012

The explanation of resonance given in IEEE Std C57.149-2012 to define resonance during frequency response analysis (FRA) measurements on transformers implicitly uses the conditions prevalent during resonance in a series R–L–C circuit. This dependence is evident from the two assertions made in the definition, viz., resulting in zero net reactive impedance, and, accompanied by a zero value appearing in the phase angle of the frequency response function. These two conditions are satisfied (at resonance) only in a series R–L–C circuit and certainly not in a transformer, as has been assumed in the Standard. This could be proved by considering a ladder-network model. Circuit analysis of this ladder network reveals the origin of this fallacy and proves that, at resonance, neither is the ladder network purely resistive and nor is the phase angle (between input voltage and input current) always zero. Also, during FRA measurements, it is often seen that phase angle does not traverse the conventional cyclic path from +90◦ to −90◦ (or vice versa) at all resonant frequencies. This peculiar feature can also be explained using pole-zero maps. Simple derivations, simulations and experimental results on an actual winding are presented. In summary, author believes that this study dispels existing misconceptions about definition of FRA resonance and provides material for its correction in IEEE Std C57.149-2012.

5. Tank current resonance behavior and its sensitivity to detect mechanical changes in transformer winding: A new diagnostic approach

Frequency response measurement offers by far the most sensitive known technique to detect any mechanical deformation in transformer winding. By default, during this measurement, the neutral or line current is considered as the winding response. The overall sensitivity to detect a mechanical change depends not only on the response quantity and the terminal connections chosen, but, also on the arrangement of poles and zeros of the system function. Some pole-zero arrangements are inherently better suited to reveal mechanical changes. Because of this, author intended to examine whether neutral current is

indeed the best response quantity to consider or there exists any other quantity, say e.g., total shunt current of the winding (also referred to as the tank-current), to accomplish this task better. With this motivation, author compared the resonance behavior of neutral and tank current. Based on analytical derivations and actual experiments, it emerges that for detecting simulated mechanical changes, the tank-current seems to be a more competent alternative compared to neutral current. A unique feature of tank current resonance behavior has been highlighted which offers enhanced detection sensitivity, especially for interleaved windings. Possible reasons to explain why it so, are presented. This unique resonance behaviour of tank current for single isolated winding has been also found to remain unchanged even when a 3-phase winding model is considered. Author believes that this finding needs reinforcement by field trials to ascertain its viability.

6. Physical representation of a Transformer Winding by a coupled ladder network constructed from its measured frequency response

Author intended to address and resolve the earlier limitations reported in the literature and proposed a new genetic algorithm-based technique to construct a ladder-network model from the measured DPI. For the sake of clarity, initially the method was demonstrated for a single isolated winding. Results were obtained for a model coil and two actual transformer windings (air-cored) and the good agreement between other system responses (viz. TF, a neutral-end measurement and voltage responses i.e. ratio of spectrum of voltages appearing across the sections and the spectrum of excitation voltage) compared with measured data clearly demonstrates its capability. Future work will be to extend this method to accommodate multiple windings and core.

7. Enhancing Physical Resolution of Constructed Ladder Network for an Interleaved Winding

The number of detectable natural frequencies in a frequency response governs the number of sections of the ladder network that can be constructed, starting from the measured frequency response data. This number, particularly in case of interleaved windings, is woefully small rendering the entire exercise pointless. Author described an attempt wherein this physical resolution can be enhanced. This is achieved by augmenting the measured driving-point admittance data (of the interleaved winding) with information regarding natural frequencies that are observable, and hence extractable, from an additional measurement of the open-circuited neutral-end voltage spectrum. By this process, a few more additional natural frequencies become available for processing, resulting in a ladder network with an increased physical resolution, i.e., more number of sections. Measurements done on an actual interleaved winding demonstrates feasibility of the proposed method.

8. How effective is the Interleaved Winding in suppressing natural frequencies- experimental study and establishment of an analytical basis

Ideally, it is desirable to design and manufacture a transformer winding that can render all its internal resonances non-excitable. This study examined the effectiveness of an interleaved winding in achieving this goal. While investigating its effectiveness, it led to the establishment of a much desired theoretical basis that reinforces the reasons put forward in the literature to explain internal insulation failures observed in interleaved windings used in EHV transformers. Numerical calculations along with experimental verification on actual transformer windings were presented. This study reveals that most of the natural frequencies that are normally non-excitable in the line and neutral current responses of an interleaved winding have been rendered excitable in the disk-to-disk voltages, thus, providing favorable conditions for insulation overstress because of resonant over-voltages. Prevalence of such a condition is an inherent characteristic of interleaved windings.

9. Network-Function-Loci for Localization of Discrete Change in a Transformer Winding

Here, the author proposed a different approach to localize the winding deformation in a transformer. Within the context of my work, winding deformation means, a discrete and specific change imposed at a particular position on the winding. The proposed method is based on the principle of pre-computing and plotting the complex network-function loci (Driving-Point Impedance loci used as nomogram) at a selected frequency, for a range of values for each element (increasing and decreasing) of the ladder network (considered to represent impulse behavior of the winding). After introducing a discrete change in the winding (to simulate a deformation), the driving-point impedance (amplitude and phase) is measured again at the same frequency. Based on plotting this single measurement on the nomogram, it is possible to estimate the location and

identify the extent of change. In contrast to earlier method (wherein the entire ladder-network had to be synthesized each time corresponding to every new measurement), the method is fast, non-iterative and yields reasonably accurate localization. Experimental results for a model coil and an actual isolated transformer winding are encouraging and illustrate the underlying idea and demonstrate its simplicity.

* * *

Encl. Award Certificates:

1. Young Researcher Award

ISH 2013

18th International Symposium on High Voltage Engineering

August 25~30, 2013 | Seoul, Korea

Young Researcher Award

The 18th International Symposium on High Voltage Engineering is pleased to confer the Awards to

Saurav Pramanik

Indian Institute of Sciene, India

for the Outstanding Scientific Research and Excellent Presentation entitled

"Estimating Series Capacitance from Measured Fra-Single Isolated and 3-Φ Transformer Winding Results"

구 자 윤

Prof. Ja-Yoon KOO, Hanyang University

Chairman of the Organizing Committee, ISH 2013
Chairman of CIGRE-Korea
Chairman of the Korea Electricity Regulatory Commission
President of the Korea Institute of Electrical Engineers (2012)

2. POSOCO Power System Award

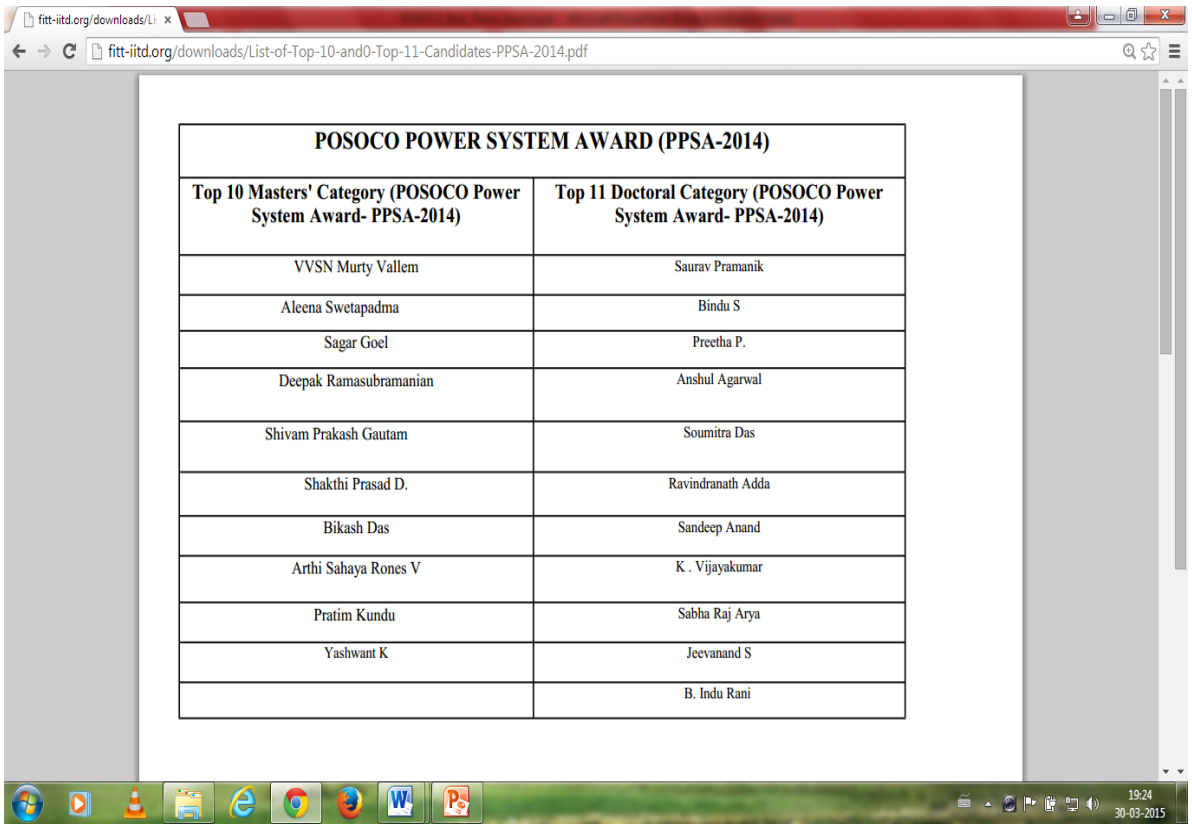
POSOCO Power System Award (PPSA-2014)

Certificate

This is to certify that
Mr/Ms Saurav Pramanik
has been conferred with the
POSOCO Power System Award (PPSA-2014)
under the Doctoral category for his/her research work on
"Frequency and Time Domain Response Analysis of Transformer Winding for Indirect Measurement of Series Capacitance and Construction of Ladder Network Models"
This award is organized by
Power System Operation Corporation Limited
(A wholly owned subsidiary of Power Grid Corporation of India Limited)
in partnership with
Foundation for Innovation and Technology Transfer, IIT Delhi

(S.K.Soonee)
Chief Executive Officer
POSOCO, New Delhi

(Dr. Anil Wali)
Managing Director
FITT



fitt-iitd.org/downloads/List-of-Top-10-and0-Top-11-Candidates-PPSA-2014.pdf

POSOCO POWER SYSTEM AWARD (PPSA-2014)	
Top 10 Masters' Category (POSOCO Power System Award- PPSA-2014)	**Top 11 Doctoral Category (POSOCO Power System Award- PPSA-2014)**
VVSN Murty Vallem	Saurav Pramanik
Aleena Swetapadma	Bindu S
Sagar Goel	Preetha P.
Deepak Ramasubramanian	Anshul Agarwal
Shivam Prakash Gautam	Soumitra Das
Shakthi Prasad D.	Ravindranath Adda
Bikash Das	Sandeep Anand
Arthi Sahaya Rones V	K . Vijayakumar
Pratim Kundu	Sabha Raj Arya
Yashwant K	Jeevanand S
	B. Indu Rani

Web-link for citation of the best thesis award in doctoral category:
http://fitt-iitd.org/downloads/List-of-Top-10-and0-Top-11-Candidates-PPSA-2014.pdf