



ERCIM "ALAIN BENSOUSSAN"
FELLOWSHIP PROGRAMME



Scientific Report

First name / Family name	Kaveri Bhuyan
Nationality	Indian
Name of the <i>Host Organisation</i>	NTNU, Trondheim, Norway
First Name / family name of the <i>Scientific Coordinator</i>	Kjetil Uhlen
Period of the fellowship	01/10/2014 to 30/09/2015

I – SCIENTIFIC ACTIVITY DURING YOUR FELLOWSHIP

During this fellowship period, I was associated with different research works at NTNU and LEMCKO (an association of distributed energy resources laboratories DER lab (<http://www.der-lab.net/>), (<http://www.lemcko.be/>)), Ghent University, Kortrijk, Belgium. Brief description of my research works are given below.

1. Developing the Next Generation of Protection System using ICT in Smart Grid

The primary objective in this project was to perform research to develop applications of Phasor Measurement Units (PMUs) and demonstrate its improved application in advanced monitoring and control solutions to ensure security and reliability in operation

of interconnected power transmission systems. I started to work focusing on current applications of Wide Area Measurement systems (WAMs). I had reviewed the state-of-the-art of recent advancements in the field of Synchrophasor technologies for increased understanding of current status and needs including future scenarios of operation of smart power grids. In this respect, the role of PMUs in preventing cascading failures because of interaction between ICT and power grid in the future Smart Grid is indispensable. LabVIEW (National Instruments, 2014) is a system design software and it facilitates the process of acquiring the phasor measurements from the PMUs making them easily available for application development. I had learnt and used LabVIEW for application development of PMUs. This research activity has formed the basis for further study of applications of PMUs and make necessary computational and experimental research to improve monitoring, and control operation in future power systems.

2. GARPUR: Generally Accepted Reliability Principle with Uncertainty modelling and through probabilistic Risk assessment

GARPUR (www.garpur-project.eu) is a collaborative R&D project co-funded by the European Commission (7th Framework Programme). The GARPUR project designs, develops, assesses and evaluates such new reliability criteria to be progressively implemented over the next decades at a pan-European level, while maximizing social welfare. The main objectives of this project is to determine probabilistic security criteria enabling flexible power transfer limits, to illustrate how to determine transmission capacity limits and how to enforce or change them in on-line operation. I had the opportunity to learn the state of the art on reliability assessment in power systems, current practices, drivers and barriers for new reliability standards while working on this project for few weeks. The main idea was to develop a sound and general methodology to both assess and optimize power system reliability of future power systems.

3. Power Quality Assessment in Micro-grid

I had visited LEMCKO Distributed Energy Resources Laboratory (DERLab), Ghent University, Kortrijk, Belgium in March 2015. Here, I was involved in projects to investigate power quality and stability issues in islanded micro-grids. The main motivation was to investigate frequency and voltage stability issues related to photovoltaic micro-

generation. My research interest was to explore and get an overview of system performance issues that may arise because of photovoltaic inverter based generation (and load) technologies. I had focused on modeling and validation of a single-phase photovoltaic inverter and synchronous generator for power quality studies in stand-alone operation. The main idea was to analyze stability issues in photovoltaic inverters and synchronous generators used in micro-cogeneration system and to investigate effects of increased penetration of residential photovoltaic generation on distribution systems of future power systems.

II – PUBLICATION(S) DURING YOUR FELLOWSHIP

Part I: Articles (published/communicated/under preparation) related to ongoing projects at NTNU and LEMCKO.

1. **Kaveri Bhuyan** and Kjetil Uhlen, “Monitoring and Control Applications of Synchronized Wide Area Information in Smart Grid, 19th Power Systems Computation Conference (PSCC 2016), 20th to 24th June 2016 in Genoa, Italy (abstract accepted).
2. **Kaveri Bhuyan** and Kjetil Uhlen, “Paradigm of State Estimation in Smart Power Grid”, IEEE International energy conference ENERGYCON 2016, Leuven, Belgium, 4th-8th April 2016 (abstract accepted).
3. Emilie Brunsgård Ek, **Kaveri Bhuyan** and Kjetil Uhlen, “Utilization of Phasor Measurement Unit Measurements as Basis for Power System State Estimation Interface” (manuscript under preparation).
4. **Kaveri Bhuyan** and Kjetil Uhlen, “Applications for Wide Area Monitoring, Analysis and Control” (manuscript under preparation).
5. **Kaveri Bhuyan et. al.**, “Power Quality Assessment in Microgrid”, (manuscript under preparation).
6. **Kaveri Bhuyan** and Kjetil Uhlen, “[Real-Time Intelligent Monitoring and Operation Using Synchronized Wide Area Information](#)”, ERCIM News special theme: Trustworthy Systems of Systems Safety & Security Co-engineering, Number 102, July 2015.
7. **Kaveri Bhuyan**, Saibal Chatterjee, "[Vulnerability Analysis and PMUs as Next Generation Protection System in Smart Grid](#)", IEEE International Conference on

Power Electronics, Drives and Energy Systems Conference (PEDES), Indian Institute of Technology, Bombay (IITB), India, 16th-19th December 2014.

Part II: Articles related to my previous research works which are communicated and published during ERCIM fellowship period

8. Pankaj Barah, **Kaveri Bhuyan**, "[India: Endangered species damned by dams.](#)" **Nature** (correspondence), vol. 515, pp. 37-37, November 2014.
9. **Kaveri Bhuyan**, Saibal Chatterjee, "[Simulation of Overvoltage Stresses on Surge Arrester Insulation](#)", International Transactions on Electrical Energy Systems (John Wiley & Sons, Ltd.), DOI: 10.1002/etep.2130, Article first published online: 11 Sep 2015.
10. **Kaveri Bhuyan**, Saibal Chatterjee, "[Electric Stresses on Transformer Winding Insulation under Standard and Non-Standard Impulse Voltages](#)", Electric Power Systems Research (Elsevier), Vol. 123, pp. 40-47, June 2015.
11. **Kaveri Bhuyan et al.**, "[Simulation and Analysis of Impulse Faults in Power Transformer](#)", Industrial Engineering, Management Science and Applications 2015, Springer, Germany pp. 135-141, June 2015.
12. **Kaveri Bhuyan**, Saibal Chatterjee, "[Simulations of Lightning Impulse Residual Voltage Test of Surge Arresters in MATLAB-SIMULINK](#)", 1st conference on Power, Dielectric and Energy Management at NERIST, ICPDEN 2015, NERIST, Nirjuli, India, 11-13th January 2015.

III – ATTENDED SEMINARS, WORKHOPS, CONFERENCES

1. Attended three courses (Masters and Ph.D.) in the department of Electric Power Engineering, NTNU, Trondheim, Norway:
 - i. Power system reliability (ET-8207), Week 39, 21– 25 September 2015.
 - ii. Power System Stability and Control (TET4180), spring 2015.
 - iii. Marine and offshore power systems (TET4200), spring 2015.
2. Attended on-site LabVIEW training course from 24th-25th November 2014.
3. Attended strategy-seminar of the Department of Electric Power Engineering in Ørlandet kysthotell, Norway, 22nd -23rd January 2015.
4. Presented poster on Vulnerability Analysis and PMUs as Next Generation Protection System in Smart Grid at IEEE International Conference on Power Electronics, Drives and

Energy Systems Conference (PEDES), Indian Institute of Technology, Bombay (IITB), India, 16th-19th December 2014.

5. Presented a paper entitled "Impulse Faults in Power Transformer: Simulation and Analysis", at 1st conference on Power, Dielectric and Energy Management at NERIST, (ICPDEN 2015), NERIST, Nirjuli, India, 11th -13th January, 2015.

IV – RESEARCH EXCHANGE PROGRAMME (REP)

As part of my Research Exchange Programme, I had visited LEMCKO Distributed Energy Resources Laboratory (DERLab), Ghent University, Kortrijk, Belgium (<http://www.lemcko.be/>) from 9th - 30th of March 2015. My host was Prof. Jan Desmet. He had started the LEMCKO lab in 1998 and since then leading the team of specialists, who performs research, consultancy & troubleshooting on power quality, distributed generation and energy efficiency related issues. In the lab, I had investigated the interaction between PE inverters and mechanical generators in relation to frequency and voltage stability related to both harmonic loads and as load alterations on a small-scale test set up (8kW, 230V). The main idea was to analyze stability stability issues in photovoltaic inverters and synchronous generators used in micro-cogeneration system and to investigate effects of increased penetration of residential photovoltaic generation on distribution systems of future power systems.