



ERCIM "ALAIN BENSOUSSAN"
FELLOWSHIP PROGRAMME



Scientific Report

First name / Family name	KAVERI BHUYAN
Nationality	INDIAN
Name of the <i>Host Organisation</i>	CWI, AMSTERDAM
First Name / family name of the <i>Scientific Coordinator</i>	ERIC PAUWELS
Period of the fellowship	01/11/2015 to 31/10/2016

I – SCIENTIFIC ACTIVITY DURING YOUR FELLOWSHIP

My research work at CWI, Amsterdam has two strands: (a) Applications of Phasor Measurement Units (PMU) and (b) Impulse fault identification and diagnostic methods. The research on these two aspects has immensely contributed to strengthen and broaden my areas of expertise and interest. As a result, I have been able to speculate additional research efforts necessary to deal with the challenges in smart grids and find ideas for further exploration. I have also participated in the preparation of a project proposal between the Organization for Scientific Research (NWO), Netherlands and the Department of Science and Technology (DST), India. This proposal is currently under review. A brief introduction to my research works is given below:

(a) Applications of PMU

The growing penetration of distributed and intermittent renewables in the energy mix creates new challenges for electricity networks. Ensuring consistent reliability in such a context requires a high degree of situational awareness gleaned from real-time data. PMUs are an emerging technology that is playing an increasingly important role in the management of smart grids. The main objective of this work was to get an insight into the state of the art and potential impact of PMUs in improving situational awareness in smart grid technology, in the following domains:

- **Monitoring and visualization:** frequency, voltage, phase angles, detecting oscillations.
- **Analysis:** Operate the grid according to real-time dynamic limits; determine causes of system disturbance, validation of models.
- **Protection:** Identify grid events and adaptive design, execution and evaluation of appropriate system protection measures.
- **Control:** Initiate corrective measures for angular and voltage stability, low-frequency oscillations and thermal constraints.

In future work, I would like to focus on modelling PMUs to extract and aggregate useful information from PMU data for improving State Estimation to increase situational awareness, identify and analyze smart grid vulnerabilities in real-time.

(b) Impulse fault identification and diagnostic methods

This part of my research work is focused on identification and classification of insulation failures in transformer winding under impulse excitation. This research is important to better understand power transformer behavior by detecting faults and also to begin examining trends and the behavior of the equipment under different fault conditions. During impulse voltage excitation, failures may occur in transformers if the voltage across the insulation exceeds certain limits. For this investigation, shunt and series failures are emulated in a model of 33 kV winding of 3 MVA transformer. Resulting winding currents of insulation failures from the transformer model are recorded. It is observed that the nature of winding currents has distinct variation for different location, nature, type of single and simultaneous

insulation failures. The first objective of this work is to extract significant features from winding currents for accurate identification of failure characteristics i.e. locations, nature(s) and type of failures. The second objective is to use statistical learning methods for detection and classification of faults.

II – PUBLICATION (S) DURING YOUR FELLOWSHIP

1. Kaveri Bhuyan, Abdolrahman Khoshrou and Eric Pauwels, “Wide area monitoring, analysis, protection and control in smart grid using synchronized phasor measurements: a review”, Energy Systems Conference 2016 (Elsevier), QEII Centre, Westminster, London, UK, 14-15 June 2016.
2. Kaveri Bhuyan, Mudang Taro and Saibal Chatterjee, “Simulation of Lightning Impulse Voltage Stresses in Underground Cables”, IEEE 2nd International Conference on Condition Assessment Techniques in Electrical Systems 2015 (CATCON 2015), Central Power Research Institute, Bengaluru, India, December 10th-12th 2015.
3. Kaveri Bhuyan and Eric Pauwels, “Phasor measurement based applications in smart grid” (Under preparation).
4. Kaveri Bhuyan and Eric Pauwels, “Fault analysis in power transformer” (Under preparation).

III – ATTENDED SEMINARS, WORKHOPS, CONFERENCES

1. Workshop on the mathematics of future energy systems
Event date: Mon, 06/06/2016 - 10:00 - 18:00
Location: Turing room, WCW Conference Halls, Science Park 123
Amsterdam
2. The Dutch national Symposium of Software Engineering (SEN)

Event date: 21.01.2016 - 09:00 - 17:30

Location: WCW Colloquiumzalen, Science Park 125, Amsterdam

3. Lectures by prof. Yuying Li, A Data Driven Approach to Pricing and Risk Management

Event date: 26.04.2016 - 10:00 - 12:00

Location: CWI, Science Park 123, room L120

IV – RESEARCH EXCHANGE PROGRAMME (REP)

I have done my research exchange visit from 21st -27th of September 2016. The Fraunhofer Institutes for Wind Energy and Energy System Technology (IWES), located in Kassel, Germany. IWES is combining their profound experiences with two other research institutes namely the Fraunhofer Institute for Integrated Circuits (IIS), and Fraunhofer Institute for Solar Energy Systems (ISE) in order to develop a joint energy management gateway platform. I have participated in learning the “OGEMA” software during my visit. OGEMA stands for “Open Gateway Energy Management Alliance”. OGEMA provides an open software platform for energy management which links the customer’s loads and generators to the control stations of the power supply system and include a customer display for user interaction. In this way end customers will be able to automatically observe the future variable price of electricity and shift energy consumption to times when the price is low.

During my stay there, I presented my research contributions and areas of interest, and I had productive meetings and experienced rich interactions with some of the group’s of the institute. Different possibilities of establishing future collaborations were also explored during my visit. It was a very positive experience and I really hope that the interactions and collaborations with that team will continue in the future.