



20<sup>th</sup> National Power Systems Conference  
**NPSC - 2018**



**Tutorial – I**

**Theme: Protection in Modern Power Systems**

**Modern Power System Protection Practices and Applications  
for Smart Grids and Microgrids**

By

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**Abstract**

This tutorial will cover three major topics:

- Out-of-Step Protection, WAMS Based Real-Time Power System Stability Prediction and Controlled Islanding
- Microgrid Protection
- Recent Developments in Distance Protection Application

The abstracts for each of the topics are given below:

**1. Out-of-Step Protection, WAMS Based Real-Time Power System Stability Prediction and Controlled Islanding:**

This part of the tutorial will discuss industry-based methods and methods currently under R&D phase for out-of-step protection of generator and transmission lines such as multiple quadrilateral blinder scheme, swing center voltage method, and possible future schemes -- equal area criterion method and power versus integral of accelerating power method.

The tutorial will also discuss WAMS based real-time stability prediction using actual PMUs and real-time controlled islanding in power systems. It will discuss briefly methods for “when to island” using protection functions and “where to island” using graph theoretic analysis. Results using electromagnetic transient simulation and RTDS studies will be presented.

## **2. Microgrid Protection:**

Microgrid is an emerging technology integrating distributed energy resources for an efficient, resilient and reliable electric system. The functionality of interfacing converters with current limiting and other control algorithms modulates the current and voltage differently during fault in the system. Available distribution protective devices cannot reliably protect such systems due to the variable and often limited short-circuit capacities of microgrids. Sub-transmission protection relays such as directional overcurrent, distance, and differential relays are the candidates for the task as of today. Centralized protection with dedicated communication system is an alternative.

DC microgrid is a recent concept, where the fault current is regulated by converter control and simultaneously the DC bus capacitor discharges through the fault. Conventional current magnitude-based protection schemes are not suitable for DC microgrid. Protection scheme using the oscillation frequency and associated transient power is one of the different options available.

The presentation will include several examples on issues and solutions on microgrid protection.

Solar photo voltaic (PV) based distributed generation systems are now being increasingly integrated. Fault in solar panel may lead to damage, fire and microgrid management issue. Detection of PV panel fault is also addressed in this presentation.

## **3. Recent Developments in Distance Protection Application:**

The current generation of protection system is towards communication and protection functionality in same devices commonly known as Intelligent Electronic devices (IEDs). This brings new challenges and given flexibility to design complex algorithms for reliable protection applications. Distance protection is one application which requires multiple facet of operation complexity depending upon the system scenarios. Earlier days distance protection has single loop which was selected by general starting element and based on the fault type selection the loop chooses voltage, current and perform the impedance comparison to trips the line. There was a time when parallel operation of blinder characteristics was causing the delay in operation. Present day's numerical relays architecture has given immense possibility to run all the 6 loops and multiple zones in parallel in real time without having any additional delay. But this brings another level of challenges also to the algorithm design e.g. the general starting elements is now replaced with 6 loop faulty phase identification which need to operate reliably for very complex power system applications. Thus, present distance protection is not an individual relay, it is a complex scheme which need to be operated and adapted under various complex system scenarios.

To affirm the reliable operation, standardization on benchmarking the functional testing of these relays is an important activity happened in recent times. Various system scenarios are identified in IEC 600255-121 standard and CIGRE reports to ensure a safe and secure operation of distance relays. Example behavior of distance protection for different system impedance ratios (SIR), infeeds, weak end infeed, evolving faults, and simultaneous faults are some of the scenarios which ensures the reliable design of distance protection application.

The talk will go through the modern practices in distance protection application scenarios and its verification challenges addressed by its design.

### Biography



**Dr. Ramakrishna (Rama) Gokaraju** graduated with Distinction in Electrical and Electronics Engineering in April 1992 from the Regional Engineering College (National Institute of Technology), Trichy, India. He obtained M.Sc. and Ph.D. degrees in Electrical & Computer Engineering from the University of Calgary, Calgary, Canada in June 1996 and May 2000, respectively. He joined the Department of Electrical & Computer Engineering at the University of Saskatchewan as an Assistant Professor in 2003, received tenure/Associate Professorship in 2009, and became a professor in 2015.

Dr. Gokaraju's research is in the area of power system protection and control, smart grid applications, and sustainable energy systems. His current areas of research are in High Speed Digital Relaying, PMU based solutions for Wide Area Protection & Transient Stability Protection, Fault Location, and Sustainable Energy Systems. He has published 80 plus papers in major journals and international conferences. He is a registered professional engineer in the Province of Saskatchewan.



**Dr. Ashok Kumar Pradhan** received the Ph.D. degree in Electrical Engineering from Sambalpur University, Sambalpur, India, in 2001. He has been with the Department of Electrical Engineering, Indian Institute of Technology, Kharagpur, India, since 2002, where he is a Professor. His research interests include Power System Relaying and Monitoring. Prof. Pradhan is a Fellow of the Indian National Academy of Engineering, India and Fellow of National Academy of Sciences, India.



**Dr. Sachin Srivastava** was born in a small town of Sitapur, Uttar Pradesh in India in 1980. He received his M.Tech. in power Systems from Malaviya National Institute of Technology, Jaipur in 2004 and Ph.D. in field of power system protection from Electrical Engineering Department, Indian Institute of Science in 2016.

He has over 14 years of experience in the power sector. He is currently working as a Principal Engineer in Power Grid Automation R&D at ABB Ability innovation Centre in Bangalore, looking after the Protection applications development team. He has also worked in power system division of central Power research Institute prior to joining ABB.

His major area of work is Distance protection, Fault location and traction protection applications. He is a main application developer of distance protection in ABB REL650 relays. He has 8 patents and 20 papers published in national and international conferences and journals. He is a senior member of IEEE, CIGRE and IET. He is a regular member, representing India in various working groups of CIGRE. Presently he is working with WG C4.B5.41: "Challenges with series compensation application in power systems when over compensating lines" and WG B5.48: "Protection for developing network and different characteristics of generation"

He has carried out various assignment of consultancy and test studies to utilities in the field of Power system simulation, Power System Planning and Power System Protection. Some major areas are +/- 800kV NER-AGRA HVDC feasibility study for PGCIL, Transmission planning till 132kV network for NR, ER, and NER grids of India, Testing Series capacitor protection of Allahabad-Manipuri circuit and Designing a Load Shedding and restoring scheme for BALCO Korba.