



## PowerTech 2009

28 June - 2 July 2009, Bucharest, Romania

- Innovative ideas toward the Electrical Grid of the Future -



[Home](#) | [Contact Us](#)

### PowerTech 2009 Main Menu

- » [Home](#)
- » [Call for Papers](#)
- » [Committees](#)
- » [Topics](#)
- » [Dates](#)
- » [Basil Papadias Award](#)
- » [Submission of papers](#)
- » [Program](#)
- » [Registration](#)
- » [Conference Venue](#)
- » [Accommodation](#)
- » [Technical visits](#)
- » [Tourist trips](#)
- » [Travel](#)
- » [General Information](#)
- » [Sponsors](#)
- » [Contact](#)

## Home



### Invitation

On behalf of the International Steering Committee and the Local Organizing Committee we invite you to attend the IEEE BPT2009. The Bucharest PowerTech Conference continues the tradition of the Power Tech Conferences held in odd years in Athens, Stockholm, Budapest, Porto, Bologna, St. Petersburg and Lausanne. PowerTech is the anchor conference of the IEEE Power & Energy Society in Europe. It is intended to provide a forum for scientists and engineers interested in electric power

engineering to share ideas, results of their scientific work, to learn from each other as well as to establish new friendships and rekindle existing ones.

The PowerTech Conference provides a bridge between generations. The interest from enthusiastic young practicing engineers and PhD students wishing to publish their work increased from event to event. The most valuable IEEE student work is recompensated with the Basil Papadias award, which has been also an important ingredient toward the event's success.

The event is sponsored by the IEEE Power & Energy Society and will be organized by University POLITEHNICA of Bucharest, National Power Grid Company TRANSELECTRICA S.A. and IEEE PES Romania Chapter.



University  
POLITEHNICA  
of Bucharest



National Power  
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For questions or comments, please contact the [PowerTech 2009 Webmaster](#).

Dear Author,

On behalf of the 2009 IEEE Bucharest PowerTech Conference, I am pleased to inform you that your paper #683, titled

“Performance of Distance Relays in Presence of IPFC”

authored by: M. Pouyan, F. Razavi, M. Rashidi-Nejad

has been accepted for presentation at the 2009 IEEE Bucharest PowerTech Conference, which will be held from 28<sup>th</sup> June to 2<sup>nd</sup> July 2009 at the Parliament Palace, Bucharest “ Romania. Publication in the Proceedings is conditioned by payment of appropriate fee.

Information about registration will be posted on the conference website in a few days. Note also that the Provisional Technical Program will be available in short time.

We are looking forward to seeing you in Bucharest,

Mircea Eremia  
Conference Chair

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Mircea EREMIA, Professor

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# **IEEE Bucharest PowerTech Conference**

28 June – 2 July, 2009

**Provisional<sup>\*)</sup>**

## **Technical Program**

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<sup>\*)</sup> Some sessions may shorten in case of non-registration

**Session: Protection Systems I**

**Chair:**

**Room: “Drepturile Omului” Hall – HR**

**Time: Monday, June 29, 14.00 – 15.45**

- 32 **Impact of SSSC on the Digital Distance Relaying**  
A. Salemnia (Power and Water University of Technology, Tehran, Iran), M. Khederzadeh (Power and Water University of Technology, Tehran, Iran), A. Ghorbani (Power and Water University of Technology, Tehran, Iran)
- 101 **Distance Protection Algorithm for Power Transmission Lines Based on Monte-Carlo Method**  
Marija Zima-Bockarjova (Swiss Federal Institute of Technology (ETH), Switzerland), Antans Sauhats (Riga Technical University, Latvia), Jevgenijs Kucajevs (Riga Technical University, Latvia), Natalja Halilova (Riga Technical University, Latvia), Gregory Pashnin (Riga Technical University, Latvia)
- 131 **Improved Operating Scheme Using an IEC61850-based Distance Relay for Transformer Backup Protection**  
Hyung-Kyu Kim (Myongji University, Korea), Sang-Hee Kang (Myongji University, Korea), Soon-Ryul Nam (Myongji University, Korea), Sea-Seung Oh (Myongji University, Korea)
- 254 **Distance Protections Coordination Using the Exchange of Binary Signals in the IEC61850 Protocol**  
Ryszard Kowalik (Warsaw University of Technology, Poland), Marcin Januszewski (Warsaw University of Technology, Poland)
- 665 **Transmission Lines Distance Protection Using Artificial Neural Networks**  
Ricardo Caneloi dos Santos (Universidade Federal do ABC, Brazil), Eduardo Cesar Senger (Universidade de Sao Paulo, Brazil)
- 683 **Performance of Distance Relays in Presence of IPFC**  
Mojtaba Pouyan (Tafersh University, Iran), Farzad Razavi (Tafersh University, Iran), Masoud Rashidi-Nejad (Bahonar University, Kerman, Iran)
- 770 **Distance Relaying Algorithm Using a DFT-based Modified Phasor Estimation Method**  
Dong-Gyu Lee (Myongji University, Korea), Ye-Jun Oh (Myongji University, Korea), Sang-Hee Kang (Myongji University, Korea), Byung M. Han (Myongji University, Korea)

# Performance of Distance Relays in Presence of IPFC

M. Pouyan, F. Razavi, M. Rashidi-Nejad

**Abstract--** In this paper, the analytical and simulation results of the application of distance relay for the protection of transmission line incorporating Inter-line Power Flow Controller (IPFC) are presented. Firstly a detailed model of the IPFC and its control is proposed and then it is integrated into the 8-bus transmission system for the purposes of accurately simulating the fault transients. The simulation results show the impact of different operational mode of IPFC on the performance of a distance protection relays.

**Index Terms--** Flexible ac transmission system (FACTS), inter-line power flow controller (IPFC), distance protection relay, power system protection.

## I. NOMENCLATURE

|           |  |
|-----------|--|
| $P_{se1}$ | Real power injected to ac line by VSC1.  |
| $P_{se2}$ | Real power injected to ac line by VSC2.  |
| $V_{pq}$  | Injected voltage   |
| $V_{1p}$  | Inphase component of injected voltage with respect to ac line current $I_1$    |
| $V_{1q}$  | quadrature component of injected voltage with respect to ac line current $I_1$ |
| $V_{2p}$  | Inphase component of injected voltage with respect to ac line current $I_2$    |
| $V_{2q}$  | quadrature component of injected voltage with respect to ac line current $I_2$ |
| $V_{1m}$  | Injected voltage magnitude of VSC1   |
| $V_{2m}$  | Injected voltage magnitude of VSC2   |

## II. INTRODUCTION

THE use of flexible ac transmission system (FACTS) controllers in power system transmission has been of a great interest in recent years for increasing the power transfer capability and enhancing power system controllability and stability [1]–[2]. However, the implementation of FACTS controllers in transmission systems introduces new power system issues in the field of power system protection. Amongst the different types of FACTS controllers, Inter-line power flow controller (IPFC) is considered to be one of the most effective in the control of power flow. In its general form, the IPFC employs a number of dc to ac converters, each providing series compensation for a different line. The converters are linked together at their dc terminals and

connected to the ac systems through their series coupling transformers. With this scheme, in addition to providing series reactive compensation, any converter can be controlled to supply active power to the common dc link from its own transmission line. In the IPFC structure, each converter has the capability to operate a stand-alone SSSC [3]–[4].

Because of the presence of IPFC controllers in a fault loop, the voltage and current signals at the relay point will be affected in both the steady state and the transient state. This in turn will affect the performance of existing protection schemes, such as the distance relay which is one of the very widely used methods in transmission line protection [5]–[6].

Some researches have been done to evaluate the performance of a distance relay for transmission systems with FACTS controllers. In [7] the authors have studied the effect of STATCOM on a distance relay at different load levels. The work in [8] has presented a study of the impact of FACTS on the tripping boundaries of distance relay. The work in [9] shows that thyristor-controlled series capacitor (TCSC) has a major influence on the mho characteristic, in particular the reactance and directional characteristic, making the protected region unstable. The study in [10] also shows that the presence of FACTS controllers in a transmission line will affect the trip boundary of a distance relay, and both the parameters of FACTS controllers and their location in the line have an impact on the trip boundary. In [11], the impact of midpoint shunt-FACTS compensated line on the performance of a stand-alone single distance relay has been studied. Reference [12] shows that the series capacitor affects the distance protection and proposes a mitigative method by using new communication-aided schemes. The authors in [13] have studied the effect of UPFC on a distance relay and an apparent impedance calculation procedure based on the power frequency sequence component is then investigated. In [14], the performance of various distance protection schemes for different fault types, fault locations and system conditions, on transmission lines with shunt-FACTS devices applied for midpoint voltage control has been evaluated.

All the studies clearly show that when FACTS controllers are in a fault loop, their voltage and current injections will affect both the steady state and transient components in voltage and current signals, and hence the apparent impedance seen by a conventional distance relay is different from that for a system without FACTS.

Some works, which are mentioned above, have investigated the impact of FACTS devices on distance relays, but none of them have been conducted to investigate the IPFC's impact. The present work is evaluating the performance of distance protection relays in presence of IPFC using PSCAD and is

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