Lecture Notes in Electrical Engineering 575

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Kunal Das *Editors*

Computational Advancement in Communication Circuits and Systems

Proceedings of ICCACCS 2018

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Preface

It is an immense pleasure to release the Proceedings of 2nd International Conference on Computational Advancement in Communication Circuit and System (ICCACCS 2018) which was organized by Narula Institute of Technology, Agarpara, Kolkata, India, on November 23–24, 2018. In this conference, we received 84 papers for consideration. Finally, after reviewing all the papers by an expert reviewer, we accepted only 42 papers for publishing in Springer Lecture Note on Electrical Engineering.

The aim of the conference was to bring together national and international researchers, industrial experts and academicians to present papers and generate discussions on current research and development in the state-of-the-art technologies in computing and communication, environment-friendly computing, reconfigurable computing and low-power nanotechnology and VLSI design, and it provided a forum for sharing insights, experiences and interaction on various facets of evolving technologies and patterns related to computer science, information technology, electrical and electronics, etc. The investigation, simulation, analysis and solving complex issues and phenomena in the areas of computation, communication circuit and system design in engineering also represented the current state-of-the-art technology and the outcome of the ongoing research in the area of advanced applied science and engineering.

We would like to take this opportunity to thank all esteemed authors for contributing their research work to this conference. We were able to obtain the quality of research article only because of esteemed reviewers which will be published in this Springer Lecture Note. We are extremely thankful to them for their effort and time in reviewing the papers critically. We express our gratitude to Prof. Bhargav B. Bhattacharya, ISI, Kolkata, for reviewing the papers even during the travel around the USA. We respect the dedication and efforts that were made by our reviewers to make this Lecture Note qualitative. We are thankful to the management of Narula Institute of Technology, Mr. Taranjit Singh and Mr. Simarpreet Singh, for their continuous support and trust. Our sincere thanks to Mr. Aninda Bose, Editor, Springer Lecture Note, Springer India Pvt. Ltd., for his cooperation and support. Special thanks to all faculty members, advisory committee, organizing committee, student and staff members of Narula Institute of Technology for their hard work.

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About the Institute

Narula Institute of Technology is a leading autonomous engineering and management college, located at Agarpara near Kolkata under the aegis of JIS Group Educational Initiatives since 2001.

Affiliations/Accreditations

It is approved by AICTE and affiliated to MAKAUT, West Bengal—formerly known as West Bengal University of Technology—which has NBA-accredited degree programs in engineering. It boasts of the prestigious NIRF ranking among 150 selected institutes of India. It is also accredited by the National Assessment and Accreditation Council (NAAC). The college has also received the notable World Bank-assisted and MHRD-approved TEQIP (Phase II) grants for the advancement of technical education. It is eligible for receiving Central assistance under the recognition of 2(f) and 12(B) under the UGC Act.

Courses

The four-year B.Tech. course is imparted in the streams of CSE, ECE, EE, CE, IT, EIE and ME. The institute provides a brilliant platform for pursuing higher studies through PG courses like M.Tech. (CSE, ECE, EE—power system, CE—structural engineering), MBA and MCA. It has expanded to include diploma programs in EE, CE and ECTC under the affiliation of West Bengal State Council of Technical Education.

Research and Development

The institute boasts of a powerful R&D cell with immense contribution from the scholarly faculty members. There is an enormous repository of national and international journal publications, e-books, online lectures which have drawn nationwide attention. With the encouragement and support from the college, around ten projects funded by organizations like UGC, BRNS and AICTE are running successfully by the faculty members till date. Very recently, the ECE, CSE

Department have secured the MODROBS, SERB, AICTE-RPS Projects and Institute level DST-FIST grant is received for upgrading their Cloud Computing, Wireless Sensor Network Lab, Embedded System and Electronic Design Automation Lab, etc.

Collaborations

The college is in collaboration with Tech Mahindra, Reliance Jio Infocomm Limited, CII, NASSCOM, Aspire Disruptive Skill Foundation, Oracle, Infosys, TCS, NIT Sikkim, IIT KGP, AIT, Bangkok, and other organizations of repute. The students get an opportunity to interact in an international platform through seminars, conferences and special teaching-learning sessions. The student chapter plays a crucial role in organizing informative technical events within the campus. At present, there are five student chapters in our college: IETE student forum of Electronics and Communication Engineering Department, ICE and ASCE of Civil Engineering Department, CSI of Computer Science Engineering, Information Technology and MCA Department and Institute of Engineers India (IEI) of Electrical Engineering Department.

About the Conference

The 2nd International Conference on Computational Advancement in Communication Circuit and System (ICCACCS 2018) was held during November 23–24, 2018, at Narula Institute of Technology, Agarpara, Kolkata, India. The aim of the conference was to bring together national and international researchers, industrial experts and academicians to present papers and generate discussions on current research and development in the state-of-the-art technologies in computing and communication, environment-friendly computing, reconfigurable computing and low-power nanotechnology and VLSI design, and it provided a forum for sharing insights, experiences and interaction on various facets of evolving technologies and patterns related to computer science, information technology, electrical and electronics, etc. The investigation, simulation, analysis and solving complex issues and phenomena in the areas of computation, communication circuit and system design in engineering also represented the current state-of-the-art technology and the outcome of the ongoing research in the area of advanced applied science and engineering. Conference technical program consisted of plenary and keynote lectures, tutorial/workshop, oral presentation session, in which the leading expert from all around the world presented the state-of-the-art reviews of rapidly developing and exciting areas and reported the latest significant findings and development in all major fields of applied science and engineering. We cordially invited all to participate in this exciting conference as a presenter.

We organized the 1st International Conference on Computational Advancement in Communication Circuit and System (ICCACCS 2014) during October 30–November 1, 2014. The conference was supported by Technical Education Quality Improvement Program (TEQIP), New Delhi, India, and we had technical collaboration with IEEE Kolkata Section, along with publication partner Springer. The Proceedings of the International Conference was published by Springer Lecture Note on Electrical Engineering. https://www.springer.com/in/book/9788132222736.

In the 2nd International Conference on Computational Advancement in Communication Circuit and System (ICCACCS 2018), we encouraged all to share their research work describing original work on theories, methodologies, abstraction, algorithms, industry applications and case studies with others by submitting original paper(s). We greatly appreciated the interest of all in the ICCACCS 2018 and for their presence at Narula Institute of Technology, Kolkata, India, in November 2018.

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About the Editors

Prof. Koushik Maharatna received his B.Sc. in Physics and M.Sc. in Electronic Science from Calcutta University, Calcutta, India in 1993 and 1995 respectively. He received his Ph.D. degree from Jadavpur University, Calcutta, India, in 2002. At present he is a Chair in Signal Processing Systems Design in the School of Electronics and Computer Science (ECS) at the University of Southampton, UK and is part of the Biomedical Electronics research group. He has served as Technical Programmes Committee member in a number of prestigious IEEE Conferences and is a member of IEEE VLSI Systems Application Technical Committee. Prof. Maharatna has over 110 scientific publications in high-impact conferences and journals to his credit.

Dr. Maitreyi Ray Kanjilal is Principal at Narula Institute of Technology. She has also worked in Techno India College of Technology and Asansol Engineering College. She completed her Ph.D. in Electronic sciences. Her areas of interests include Wide-band gap semiconductor devices, nanoscale devices, heterostructures and heterojunction semiconductor devices, microelectronics fabrication, low power devices and VLSI circuits, and spintronics. She has published many papers in international journals and conferences. She has also filed a patent in 2016 titled ‘A system for generation of electricity and method there off’.

Dr. Sukumar Chandra Konar is Ex-Professor & Head of Department of Electrical Engineering, Indian Institute of Engineering Science and Technology. Presently, he is Professor and Dean of Electrical Engineering Department of Narula Institute of Technology. He has +35 years of teaching and research experience. He has published around 30 papers in international journals and conferences. Dr. Konar has also published a book titled 'Robust Stability and Performance of Analysis of Power Systems' with Lap Lambert Academic Publishing GmbH & Co. He also acts as a reviewer of many journals and conferences—Institution of Engineers (India) Journal; Taylor and Francis Journal & AMSE (France) Journal; Electric Power Components and Systems; International Journal of Sustainable Energy.

Dr. Sumit Nandi received his B.Tech., M.Tech. and Ph.D. degree from Calcutta University in Chemical Technology, Oil Technology and Processing of refinery by-products respectively. He has also completed his M.B.A. from Sikkim Manipal University in Finance and Marketing. Currently he is Head and Associate Professor in Department of Basic Sciences and Humanities, Narula Institute of Technology. His areas of research interests include preparation of biodiesel from natural resources, mathematical modelling on enzyme kinetics, enzyme-catalyzed production of different value-added products. He has published more than 50 papers in international journals and conferences in these areas.

He has also filed two patents—'A process for preparing biodiesel from Jatropha Curcas oil' and 'Interpenetrating polymer network structure and preparation method thereof'. He has published one book 'Engineering Chemistry Simplified' with Chhaya Prakashani Private Limited.

Dr. Kunal Das received his B.Sc.(H) in Electronics Science, B.Tech. (Information Technology) and M.Tech. (Information Technology) degrees from Calcutta University, Kolkata, India. He was awarded the Ph.D. degree from the University of Kalyani. He is working as an associate professor in the Department of Computer Science & Engineering, Narula Institute of Technology, Kolkata, and was the former assistant professor in the Department of Computer Science & Engineering, National Institute of Technology, Arunachal Pradesh, India. He has authored several international journal papers and several conference papers, and many SCI journals like Elsevier Microelectronics Journal, Springer JETTA, IEEE Transactions, and worked as editor in many international books. He is the recipient of Early Career Research Award Grant from SCIENCE & ENGINEERING RESEARCH BOARD (SERB), DST, Govt. of India as Principal Investigator.

Part I
Modeling of Energy Systems

Congested Power Transmission System in a Deregulated Power Market

Bishaljit Paul, Chandan Kumar Chanda, Jagadish Pal and Manish Kumar Pathak

Abstract The optimum and marginal generator dispatch in the deregulated power industry is one of the managerial tasks to eradicate congestion in the transmission lines which is necessary for the online control action in the power system. So optimum power flow has been chosen as the most versatile technique for system security through economic generated dispatch under all parameter constraints. The significance of this work is to give enough logic that in some real time systems is to manage the generator scheduling during overloading of the lines or during outage of the elements, also to know the performance index of the lines based on their contingency studies, to correct overloading by both scheduling and even by load shedding and in the event of bilateral transactions by the market participants through the concept of nodal pricing or locational marginal prices, the owners for the transactions are owned with Financial Transmission Rights which act as perfect hedge for the congestion surplus, all can relief congestion, are explained through a five-bus network.

Keywords Congestion · Congestion surplus · Contingency · Deregulation · Financial transmission rights · Locational marginal prices · Optimal power flow · Performance index

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1 Introduction

Due to deregulation and privatization of the electricity markets, there is a large impact on power transmission around the whole world. There is an obstacle among the market participants in the competitive market scenario due to the bottlenecks of transmission capability in the transmission lines [1]. So planning in the transmission lines should be meticulously done. Buyers and sellers make the electricity market very complex and competitive. Due to the limitations of the available transmission capability, the sole reason behind the complexity is the balancing of the supply and demand at all real times. A congested system arises when producers and consumers of electrical energy make the transmission lines beyond their transfer capabilities. Spots of congestion are indicated by the locational marginal prices (LMPs) [2] in the systems.

Congestion management [3] provides a market-based solution with economic efficiency for a multi-buyer and multi-seller system. For a vertically integrated utility structure, generation, transmission and distribution are within a control of a central agency. Generation is dispatched at least cost accordingly. Security-constrained economic dispatch (SCED) [4] provides an optimal solution and eliminates congestion. So the power flow limits are not exceeded in the transmission lines and the generators are dispatched accordingly. Congestion management states that the transactions are to be prioritized and committed to work in such a schedule by the system operator that does not overload the network. A set of definite rules are to be ensured and enforced by the congestion management such that it takes control over generation and loads to maintain security and reliability in the system. Under open market structure, the rules ensure market efficiency maximization and a set of market players will always look for loopholes to exploit it. Modelling of the market structure [5] in the deregulated environment will be such that the participants can engage freely for their transactions so that the security is not threatened or alarmed. Market efficiency stands [6] with respect to cost-effective generation when they are used to serve the load. The efficiency of a real market is the difference of social welfare between real market and perfect market. In a competitive electricity market, due to competiveness [7] among the market participants, overloading of the transmission lines occurs while settling the market, and so congestion prevails. In the deregulated scenario, the chances of congestion are quite high as all the customers would like to purchase electricity from the cheapest source of energy. For the secured operation of the system, the congestion should be alleviated. Optimal power flow techniques use congestion management strategies [8] like rescheduling of generators, use of compensating devices and even load curtailments to release congestion. If congestion persists for a long time, the transmission lines operate beyond the transfer limits, and there is a sudden rise in price of electricity which threatens security and reliability of the system. So congestion management is one of the challenging tasks for the system operator in the deregulated environment [9]. Optimal power flow-based congestion management minimizes the generator's operating cost subject to set of constraints based on transmission system. Though there are different levels of economic signals for different methods of congestion management, locational marginal price is the most sensitive mechanism [10] as it provides the strongest price signal to the players in the power market. They are the incremental increase or decrease of prices of energy at every bus in the congested power system. When a transmission line is constrained, another unit becomes marginal in the sense that it is neither at its maximum nor at its minimum. If there are 'p' transmission constraints in the system, there will be '$p + 1$' marginal generators [11, 12]. LMP at any bus is defined as the marginal cost of the marginal generators of supplying the next increment of electrical energy at that bus while maintaining the physical aspects of transmission system. Shadow prices are the maximum dispatch cost saved due to an increment increase of flow capacity in the line without violating transmission constraints. Shadow prices are the Lagrange multipliers for the inequality constraints. Though LMPs vary significantly from one bus to another and they are decomposed into three components; marginal energy price (MEP), marginal congestion price (MCP) and marginal loss price (MLP) are not unique due to transmission open access and large transactions [13, 14]. For an 'n' component power network, if one component is under outage, it is called '$n - 1$' contingency. Similarly, for two-component outages, it is called '$n - 2$' contingency. Security-constrained economic dispatch optimal power flow programs are analysed for the system security. If energy is bought and sold at nodal marginal prices, the payments made by the generator companies to the ISO and the revenues collected by the generator companies from the consumers do not match. More money is collected from the consumers than it is paid to the generators. The difference is called the congestion surplus or merchandising surplus, and it is caused due to the congestion in the network. In an unconstrained economic dispatch, as the marginal prices are identical at all nodes, the total amount collected by the generator companies is equal to the amount paid by the consumers. So the congestion surplus is zero.

Financial Transmission Rights (FTRs) [15–19] are defined that provide the market player holder to collect a revenue equal to the amount of flow of power of 'F' MW between two nodes and the price differential between that two nodes or buses. FTRs completely debar the risks of congestion from the network by paying the amount to the market players.

2 Mathematical Formulation

Let us consider that the line connecting the nodes 'i' and 'j' is constrained and the power flow is at its limit. So this has violated the security of the system. This causes two marginal generators to operate. Let the marginal generators be P_A and P_B. To determine the LMP and by implementing congestion management strategies [20] which are flow tariffs, costs of loads and generator bids at different buses, zero congestion surplus and by changing the reference buses [21, 22]. At any node 'k', it is required to calculate incremental inputs ΔP_A and ΔP_B of the marginal units at nodes 'l' and 'm' so as to deliver 1 MW to node 'k', without increasing the flow between the nodes 'i' and 'j' of the congested line.

From the power transfer distribution matrix (PTDF), if 1 MW of power is injected at node '*l*' where there is a marginal generator and withdrawn at node '*k*' where LMP is to be found, there may be an increase or decrease of flow in line connecting between the nodes '*i*' and '*j*'.

$$\Delta \boldsymbol{Flow}_{\mathbf{(i-j)l}} = \mathbf{PTDF}_{\mathbf{(i-j)l}} - \mathbf{PTDF}_{\mathbf{(i-j)k}} \tag{1}$$

$$\begin{bmatrix} \boldsymbol{\Delta Flow}_{(i-j)l} & \boldsymbol{\Delta Flow}_{(i-j)m} \\ \mathbf{1} & \mathbf{1} \end{bmatrix} * \begin{bmatrix} \boldsymbol{\Delta}\mathbf{P}_A \\ \boldsymbol{\Delta}\mathbf{P}_B \end{bmatrix} = \begin{bmatrix} \mathbf{0} \\ \mathbf{1} \end{bmatrix} \tag{2}$$

A similar calculation is analysed to determine the shadow price, which is direction specific, in the congested line connecting between the nodes '*i*' and '*j*'. The aim is to perturb the outputs of the marginal generators at nodes '*l*' and '*m*' by incremental amounts ΔP_A and ΔP_B so as to increase the flow in the congested line between the nodes '*i*' and '*j*' by 1 MW, while maintaining the energy balance.

The quantities must satisfy the system of equations:

$$\begin{bmatrix} \boldsymbol{\Delta Flow}_{(i-j)l} & \boldsymbol{\Delta Flow}_{(i-j)m} \\ \mathbf{1} & \mathbf{1} \end{bmatrix} * \begin{bmatrix} \boldsymbol{\Delta}\mathbf{P}_A \\ \boldsymbol{\Delta}\mathbf{P}_B \end{bmatrix} = \begin{bmatrix} \mathbf{1} \\ \mathbf{0} \end{bmatrix} \tag{3}$$

For any pair of nodes, '*i*' and '*j*', a relation between locational marginal price and shadow price (**SP**) for the congested lines (**cl**) can be formulated as

$$\boldsymbol{LMP_j - LMP_i = \sum SP_{cl} * \left(PTDF_{(h-k)j} - PTDF_{(h-k)i}\right)} \tag{4}$$

Calculation based on the method of shift factors **(SF)**, Lagrangian multipliers where **c** is the bidding price vector of generation, **P** is the energy vector, **A** is the bus unit incidence matrix and **B** is the bus-load incidence matrix.

$$\boldsymbol{Minimize} \quad \boldsymbol{c^T * P}$$

$$\text{subject to} \quad \sum_j P_{D_j} - \sum_i P_i = 0$$

$$\mathrm{PL = SF * (A * P - B * P_D) \le PL_{max}} \pi^+$$

$$\mathrm{-PL = -SF * (A * P - B * P_D) \le PL_{max}} \pi^-$$

$P_{min} \le P \le P_{max}$ for all generators.

So,

$$\mathrm{LMP} = \boldsymbol{\lambda} - \mathbf{SF^T} * \left(\boldsymbol{\pi}^+ - \boldsymbol{\pi}^-\right) \tag{5}$$

where

$$\mathrm{LMP_{energy}} = \boldsymbol{\lambda}$$

and

$$\mathrm{LMP_{congestion}} = -\mathbf{SF^T} * \left(\boldsymbol{\pi}^{+} - \boldsymbol{\pi}^{-}\right)$$

$$\mathbf{PI} = \sum_{\mathbf{l=1}}^{\mathbf{L}} \left(\frac{\mathbf{P_l}}{\mathbf{P_l^{lim}}}\right)^{\mathbf{2n}} \tag{6}$$

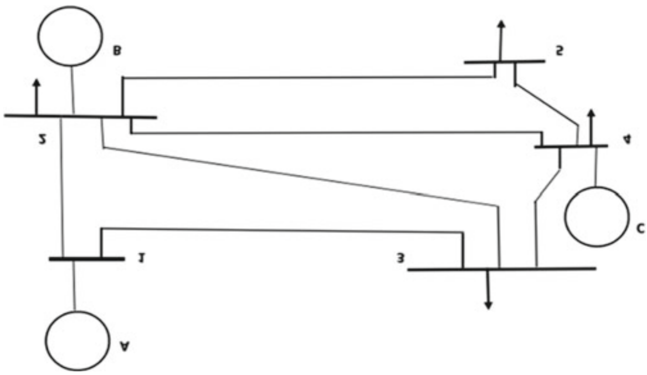
where

L Number of lines.
P_l^{lim} MW limit capacity of the line.
n a positive integer.

The cost of power transmission of a transmission line between the two nodes 'i' and 'j' is formulated as

$$\mathbf{t_{ij} = LMP_j - LMP_i} \tag{7}$$

3 An Illustration with Five-Bus Network



3.1 Generating Units and Load Information

See Table 1.

Table 1 Generating units and load information

Bus	Cost ($/MWh)	P_{min} (MW)	P_{max} (MW)	P_D (MW)	Type
1	15	0	1000	0	Slack
2	17	100	400	120	P-V
3	–	–	–	100	P-Q
4	19	50	300	80	P-V
5	–	–	–	120	P-Q

Table 2 Line parameter information

Line	From (bus)	To (bus)	X_{pu} (reactance)	PL_{max} (MW)
L_1	1	2	$j0.06$	150
L_2	1	3	$j0.24$	100
L_3	2	3	$j0.12$	50
L_4	2	4	$j0.18$	100
L_5	2	5	$j0.12$	120
L_6	3	4	$j0.03$	100
L_7	4	5	$j0.24$	100

3.2 *Information of Line Parameters*

See Table 2.

4 Results and Discussions

4.1 *Base-Case Power Flows in MW Under Economic Dispatch*

Flow 1–2	Flow 1–3	Flow 2–3	Flow 2–4	Flow 2–5	Flow 3–4	Flow 4–5
197.453 (constrained)	72.547	46.359	34.056	97.038	18.906	22.962

4.2 Correction of Overloading in the Lines Only Through Scheduling of Generators Under Security-Constrained Economic Dispatch

Minimize $15 * P_{G1} + 17 * P_{G2} + 19 * P_{G4}$

subject to, $P_{G1} + P_{G2} + P_{G4} = \text{Demand} = 120 + 100 + 80 + 120 = 420$

$-150 \leq \text{Flow in line } (1-2) \leq 150$

$-50 \leq \text{Flow in line } (2-3) \leq 50$

$0 \leq P_{G1} \leq 1000$

$100 \leq P_{G2} \leq 400$ and

$50 \leq P_{G4} \leq 300$

So,

$\Delta \mathbf{P}^{-}_{\mathbf{G1}}$ (MW)	$\Delta \mathbf{P}^{+}_{\mathbf{G2}}$ (MW)	$\Delta \mathbf{P}^{+}_{\mathbf{G4}}$ (MW)
57.4932	53.1337	4.3596

where ΔP^{-}_{G1}, ΔP^{+}_{G2} **and** ΔP^{+}_{G4} are the increases and decreases of generation. As two lines are accounted for constraint, there are three marginal generators. So with the generated amount of 212.5068 MW by P_{G1}, 153.1337 MW by P_{G2} and 54.3596 MW by P_{G4}, the congestion has been relaxed. The total cost becomes $6874/h. So the congestion cost becomes $174/h.

4.3 To Calculate the LMPs and the SPs, the Price Signals for the Buses in $/MWh

LMP_1	LMP_2	LMP_3	LMP_4	LMP_5	SP_{1-2}	SP_{2-3}
15.0	17.0	19.5	19.0	17.67	−3.1249	−6.7512

4.4 Transmission Costs in $/MWh

t_{12}	t_{13}	t_{23}	t_{24}	t_{25}	t_{35}	t_{45}
2	4.5	2.5	2	0.67	−1.83	−1.33