Skoltech
Skolkovo Institute of Science and Technology

Jury Member Report – Doctor of Philosophy thesis.

Name of Candidate: Ali Mazhar

PhD Program: Engineering Systems

Title of Thesis: Voltage Feasibility Boundaries

Supervisor: Prof. Janusz Bialek

Date of Thesis Defense: 09 December 2019

Name of the Reviewer: Petr Vorobev

I confirm the absence of any conflict of interest (Alternatively, Reviewer can formulate a possible conflict)	**Signature:**  **Date: 05-11-2019**

The purpose of this report is to obtain an independent review from the members of PhD defense Jury before the thesis defense. The members of PhD defense Jury are asked to submit signed copy of the report at least 30 days prior the thesis defense. The Reviewers are asked to bring a copy of the completed report to the thesis defense and to discuss the contents of each report with each other before the thesis defense.

If the reviewers have any queries about the thesis which they wish to raise in advance, please contact the Chair of the Jury.

Reviewer's Report

Reviewers report should contain the following items:

- Brief evaluation of the thesis quality and overall structure of the dissertation.
- The relevance of the topic of dissertation work to its actual content
- The relevance of the methods used in the dissertation
- The scientific significance of the results obtained and their compliance with the international level and current state of the art
- The relevance of the obtained results to applications (if applicable)
- The quality of publications

The summary of issues to be addressed before/during the thesis defense

The thesis is dedicated to development of new methods for solving power flow equations, that can be used even in the case of operating points, close to solvability boundary. The method also allows to incorporate additional feasibility constraints, which is especially valuable for practical applications. The thesis brings high level original contribution to the field, which is confirmed by a number of publications in the leading journals/conferences. In addition to the top level scientific value, the work is very practically oriented – it was inspired by discussion with Arkadiy Landman – the head of the JSC "Institute for Automation of Energy Systems" (IAES) – one of the leading companies, implementing wide area protection systems to Russian power grid.

Solving power flow equations is traditionally one of the hardest problems in power systems due to its nonlinearity. The problem becomes even harder when the system is close to its stability boundary and the conventional iterative algorithms (Newton-Raphson) fail to converge. Most of the methods to overcome this problem, discussed in literature, are based on a number of heuristic approaches, and do not offer any systematic approach. In the thesis of Mazhar Ali, such an approach is proposed and successfully implemented. The method of extending the original system with additional transversality conditions is rigorously justified, and then tested on a number of models, including the real models of parts of Russian grid. The method is able to successfully find the solution of power flow equations for operating points, arbitrarily close to solvability boundary. Moreover, the method naturally allows to find the distance towards this boundary, which is extremely important for practical applications. Another advantage, that needs to be mentioned, is that the method is also able to find the distance to solvability boundary for the operating points outside of it – this is a qualitative advantage, since no conventional iterative method can provide this kind of tools.

It is worth to note the practical value of the method, that was already demonstrated during the ongoing collaboration with JSC IAES on a number of practical test cases. In addition to finding solutions close to solvability boundary, the method appeared to have another practical advantage, associated with the fact, that the Jacobian of the extended system is nonsingular: it is possible to solve power flow equations for systems with very different values of impedances of lines. Such systems naturally represent a problem to conventional methods, due to almost singular Jacobian. On the other hand, the recent requirements form the System Operator for model improvement lead to introduction of detailed representation of such components as substations or transformers, which contain very low impedance components, making the network structure highly uneven. Such systems pose a great challenge for conventional iterative methods, however, the method of Mazhar Ali appeared to have excellent performance for them. This could be a decisive advantage for practical applications.

Overall, I find the thesis to be an excellent contribution to a practically important problem. The scientific contribution is of the major significance for the field, which is confirmed by a number of publications, including a paper in one of the top journals. My firm recommendation is to award the applicant a PhD degree, giving his thesis the highest grade.

Provisional Recommendation

X☐ *I recommend that the candidate should defend the thesis by means of a formal thesis defense*

☐ *I recommend that the candidate should defend the thesis by means of a formal thesis defense only after appropriate changes would be introduced in candidate's thesis according to the recommendations of the present report*

☐ *The thesis is not acceptable and I recommend that the candidate be exempt from the formal thesis defense*