LOAD FLOW ANALYSIS UNCERTAINTY TREATMENT VIA FUZZY ARITHMETIC

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ABSTRACT

Load flow analysis uncertainty treatment via fuzzy arithmetic is a method which applying fuzzy arithmetic to model vagueness, ambiguity and uncertainties in power system analysis. In this study, trapezoidal method and transformation method have been employed to solve the uncertainties in load flow analysis where LR (left-right) fuzzy arithmetic have been applied to model the uncertainties and another method is by composing fuzzy numbers into intervals by using transformation method. The fuzzy load flow has been performed to get the ouput results. The simulation study is conducted for IEEE 5-bus test system and IEEE 9-bus test system using both methods. The output voltage of the fuzzy load flow has been plotted against their membership function to validate the result in terms of fuzzy distribution and to compare which method is more efficient as solution for load flow uncertainties treatment.

ABSTRAK

Penyelesaian ketidakpastian analisis aliran beban menggunakan arithmetik kabur adalah satu cara menggunakan arithmetik kabur untuk memodelkan keraguan, kesamaran dan ketidakpastian dalam analisis sistem kuasa. Dalam kajian ini, kaedah trapezoid dan transfomasi telah digunakan untuk menyelesaikan ketidakpastian dalam analisa aliran beban di mana kiri-kanan arithmetic kabur telah diaplikasi untuk memodelkan ketidakpastian dan salah satu cara lagi ialah melalui penggubahan nombor kabur kepada jeda-jeda menggunakan kaedah transformasi. Aliran beban kabur dijalankan untuk mendapatkan keputusan. Simulasi telah dijalankan terhadap IEEE 5- bus dan IEEE-9 bus menggunakan kedua-dua kaedah. Voltan keluaran daripada aliran beban kabur diplot melawan fungsi keahliannya untuk mengesahkan keputusan dalam bentuk agihan kabur dan untuk membandingkan kaedah yang lebih efisien sebagai penyelesaian ketidakpastian aliran beban.

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Y	-	Input variables vector of the load flow
U	-	Control vector of the load flow
X	-	State variables vector of the load flow
Z	-	Output variables of the load flow
V, Vi	-	Voltage amplitude at bus i
$\delta, \delta i, \delta i$	-	Voltage phase at bus i, k
f,g	-	Function vectors of the load flow
n	-	Number of buses in the power grid
μ	-	Membership function
$\tilde{a}, \tilde{b}, \tilde{p},$	-	Fuzzy numbers
x, y, z	-	Universes of discourse
$xmax, xmin$	-	Maximum and minimum value of universe of discourse x
$X(j)$	-	Interval of the alpha- cut j, [$a(t), b(j)$]
A, B, P	-	Decomposed form of the fuzzy numbers a,b,p
m	-	Numbers of intervals or alpha cuts less one
μj	-	Membership level, $\mu j = j/m, j=0, \ldots, m$.
$(mi, \alpha i, \beta i)LR$	-	Parameters of LR fuzzy number $\tilde{a}i$
$\mu t\ (x,at,bt,ct)$	-	Triangular membership function
$\mu g\ (x,cg, \sigma)$	-	Gaussian membership function
F	-	Fuzzy- parameterized model
Fr	-	Functions of the model F, r=1,2,…..N
$\tilde{q}$	-	Fuzzy – valued output parameters of the model F
$\tilde{Z}$	-	Decomposed form of the output parameters qr
Pij, Qij	-	Active and reactive power flow of the branch ij
P', δ'	-	Active power injections and voltage phases at the operating time

P'_{ij}	-	Power flow of the branch *ij* at the operating point
$\Delta \hat{P}$, $\Delta \hat{Q}$, $\Delta \hat{\delta}$	-	Fuzzy numbers of the deviations of active and reactive power injections, and of the deviations of voltage angles from operating point
B	-	Nodal admittance matrix considering only series and shunt resistances
X_{ij}	-	Reactance of the line *ij*
Y_{ij}	-	Admittance of the branch *ij*, $\mathbf{G}_{ij} + j\mathbf{B}_{ij}$
$\hat{\mathbf{P}}$, $\hat{\mathbf{Q}}$	-	Fuzzy numbers of the active and reactive power flows by the line *ij*
$\Delta \hat{P}, \Delta \hat{Q}$	-	Power flow deviations of the line *ij* from the operating point
Y', U'	-	Operating point of the input and control vectors of the load flows
X', Z'	-	State and output vectors obtained withthe load flow on the operating point Y', U'
$\hat{Y}$, $\hat{X}$, $\hat{Z}$	-	Input, state and output vector fuzzy numbers in the fuzzy AC load flow
S, W	-	Sensitivity

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CHAPTER 1

INTRODUCTION

1.1 Project Background

Over the past few decades many power system problems (with state estimation, stability analysis contingency and security analysis, VAR management and optimization etc) have well recognized the usefulness of power flow analytical tools. The basic requirement of a power flow program is to organize a set of input data, which describe the system parameters, line parameters, bus injection and initial state variables.

Conventionally these inputs are assigned values that are crisp in nature. However, in many systems this may prove to be unrealistic as these parameters show some imprecision and uncertainty. In such cases, the information need be qualitatively soft and natural.

Fuzzy set theory offers a way to understand these problems and also allows incorporating ones own intuition, intelligence and knowledge acquired from past experiences in solving them. It is felt that these uncertainties can be properly modeled with the help of fuzzy set theory. Fuzzy arithmetic, a fuzzy load flow method arise based on fuzzy sets that finds accurate load flow solutions when uncertain nodal powers are given as fuzzy numbers. Imprecision and uncertainties in power flow analysis is modeled using fuzzy set theory.

Fuzziness on the power generation and loads used in a power flow analysis implies fuzziness on the outputs. Power flow calculations are one of the most important computational tools for planning and operating electric power systems. After the stabilization of the deterministic power flow calculation methods, the need to capture uncertainty in load definition lead first to the development of probabilistic models, and later to fuzzy approaches able to deal with qualitative declarations and other non-probabilistic information about the value of the loads.

These uncertainties present in every day and real life problem. The requirement to model the uncertainties where each uncertainties must be assigned a degree of membership that represent the degree of participation of the parameter under study so that the imprecise knowledge can be shown through meaningful probability distribution and in realistic way. The treatment of uncertainties can be shown through various approaches.

The uncertainties in load and generation of load flow has been modeled with the earliest method which is probabilistic load flow where the uncertainties in load and generations have been medelled through probability distribution or statistical moments. At the eighties, another method of uncertainty has been developed which is fuzzy load flow [1]. The uncertainties will be modeled with fuzzy numbers.

Fuzzy numbers can be implemented such as discretized fuzzy numbers, LR fuzzy numbers and decomposed fuzzy numbers, α-cuts[16].

1.2 Objective

The objectives of this project :

i. To study the conventional load flow methods where the uncertainty type of vagueness, imprecision and ambiguity of loads and generation is modelled.
ii. To identify methods of uncertainty treatment in power system analysis.
iii. To develop fuzzy arithmetic to model the uncertainties in generation and load.
iv. To validate the results for both method in terms of fuzzy distribution.

1.3 Scope

In order to achieve the objectives;

i. A study have been done to learn about the concept of fuzzy sets, the concept of power flow analysis, the equations and also the Newton Raphson Algorithm and the other load flow analysis solution, such as Fast Decoupled Method and Gauss Seidel Method.

ii. In this analysis, Left-Right fuzzy number's arithmetic and transformation method has been used as solution for fuzzy load flow solution where LR fuzzy numbers and arithmetic model the loads and generations and transformation method decomposed numbers in intervals.

iii. A few algorithms have been develop to apply according to both method.

iv. Fuzzy load flow has been applied and simulation on the IEEE 5-bus test system and IEEE 9-bus test system was conducted by using Matlab and Power World Simulator to obtain the output result.

v. Finally each of the output result will be plotted against their membership function to how and validate the uncertainties distribution of the parameter injection in terms of fuzzy distribution.

1.4 Chapter Review

In this chapter, the introduction and background of the project have been defined and later on in the next chapter, a brief explaination about load flow studies, power flow analysis, problem, equations will be discussed. Chapter three focused more on uncertainty and fuzzy arithmetic concepts together with the implementation of fuzzy numbers and fuzzy load flow methods and also the types of the fuzzy load flow will be explained clearly for better understanding.

In chapter four, the uncertainty representation and modeling of active and reactive loads and generation will be shown. In chapter five, the output results from fuzzy load flow simulation are represented and analyzed. The comparisons between the output from fuzzy load flow using LR arithmetic and transformation method will be discussed. The conclusion of this study are summarized in the chapter six together lastly a few recommendations are proposed for improving the result and also the test methods.