Ain Shams University
Faculty of Engineering
Electrical Power and Machines Department

Voltage Stability Enhancement for Electric Distribution Networks

A Thesis Submitted to the Faculty of Engineering, Ain Shams University in partial fulfillment of the requirements for the Degree of Master of Science in Electrical Engineering

Prepared by:

Eng. Mohamed Maher Salah eldeen Abdel-Basset

B.Sc. in Electrical Power Engineering
Electrical Power and Machines Department
El-Shorouk Academy

Under Supervision of:

Prof. Elsayed Abd-Elaliem Mohamed
Faculty of Engineering –Ain Shams University

Assoc. Prof. Aboul'Fotouh A. Mohamed
High Institute for Engineering, El-Shorouk Academy

Dr. Mohamed Ahmed Ebrahim
Faculty of Engineering at Shoubra –Benha University

Cairo - Egypt
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Examination committee

Title, Name, and Affiliation	Signature
Prof. Abdelghany Mohamed Abdelghany Electrical Power and Machines Department, Faculty of Engineering, Helwan University.	.....
Prof. Ahmed Rizk Abul'Wafaa Electrical Power and Machines Department, Faculty of Engineering, Ain Shams University	.....
Prof. Elsayed Abd-Elaliem Mohamed Electrical Power and Machines Department, Faculty of Engineering, Ain Shams University	.....

Date: 28 / 1 / 2018

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Prof. Elsayed Abd-Elaliem Mohamed Faculty of Engineering –Ain Shams University	
Assoc. Prof. Aboul'Fotouh A. Mohamed High Institute for Engineering, El-Shorouk Academy	
Dr. Mohamed Ahmed Ebrahim Faculty of Engineering at Shoubra –Benha University	

Date: 28 / 1 / 2018

RESEARCHER DATA

Personal Information:

Name	: Mohamed Maher Salah eldeen
Date of birth	: 22/11/1991
Place of birth	: Ismailia, Egypt
Academic Degree	: B.Sc. in electrical Engineering
Field of specialization	: Electrical power and machines
University issued the degree	: El-Shorouk Academy
Date of issued the degree	: 2013
Address	: Dahyat El-Nakheel, Cairo-Suez Road, El-Shorouk City, Egypt.
Contact No.	: +002 01067966669 and +002 01113959563
Mail to	: m.maher@sha.edu.eg

Academic Qualification:

- B.Sc. in electrical power and machines engineering from High Institute for Engineering-El-Shorouk city with an **Excellent** degree of **95.5%** (Honors' degree) – **1st** Rank; in May 2013.

Current Job:

- Instructor in Electrical Power and Machine Department, El-Shorouk Academy, Egypt; since September 2015.

STATEMENT

This thesis is submitted to Ain Shams University in partial fulfillment of the requirement for the M.Sc. degree in Electrical Engineering. The submitted work in this thesis has been carried out by the author at the Electrical Power and machine department, Ain-Shams University. No Part of this thesis has been submitted for a degree or a qualification at other university or institute.

Name: **Mohamed Maher Salah eldeen**

Signature: Mohamed Maher

Date: **28/ 1 / 2018**

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Thanks to ALLAH who gives us the power and hope to succeed.

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ABSTRACT

This thesis proposed an integrated method to deal with the voltage instability problem in radial distribution networks (RDNs). This problem arises due to the ever-increasing load demand which pushing the power systems to their stability boundaries and increases the risk of widespread of partial blackouts. The central core of this strategy is based initially on finding a method to define voltage stability boundaries and index, then the requirements of this analysis are determined. Accordingly, the appropriate solution for voltage instability can be finally found.

The proposed method implies the following main tasks ; load flow analysis for computing the bus voltage and power flow required for computing voltage stability index (SI), voltage stability analysis to evaluate the SI for each bus (node) of the system, voltage stability enhancement to mitigate voltage stability problem by applying the proposed solutions and finally economic study is implemented to choose the best solution.

The developed load flow method which based on the Forward/Backward (F/B) sweep process which is based on the ladder system theory will be capable of handling the unique properties of RDN with any number of buses and different loads to find the voltage at each bus, power flow on each branch and the total system power losses more accurately among with less time of calculation.

The SI is taken from the bi-quadratic equation which is commonly used for the voltage stability calculation of distribution load flow algorithms. A developed formula for computing the SI of all nodes of any distribution network is proposed in this thesis work. Accordingly, the weakly node having the minimum value of SI is the most sensitive node to voltage instability which may result in a voltage collapse.

Installation of DGs in non-optimal places, sizes and without selecting power factors may result in an increase in system losses;

voltage problems cause more voltage instability. Optimal DG's location and size affect the voltage stability improvement resulting an increase in system power loss and others for minimizing the system power loss resulting voltage instability trouble. Therefore, an optimization algorithm is needed so that it can find the optimal location, size, and power factor to enhance the voltage profile and minimize system power losses.

Therefore, DGs sizes and locations must be selected optimally. Optimally placement of DGs can be achieved via maximize SI or minimize the system power loses or both depending on the system characteristics and required performance, which gives the maximum reduction in system power losses and improves the voltage profile. Two new algorithms (Ant Lion optimizer and Whale Optimizer algorithm) compared with particle swarm optimization (PSO) are used for optimal locations, sizing and power factor of different DG types.

An economic analysis is implemented on the three tested systems after VS enhancement to find the most economical solution.

The proposed strategy is implemented in three tested systems, two standard systems the IEEE 33-bus, 69-bus, and also a practical system of 34-bus in Kafr Elsheikh City to evaluate its effectiveness. All the required software is developed using MATLAB as a platform. The results denote the effectiveness of the presented methodology in minimizing the system losses and improving the voltage profile.

Keywords: **Voltage stability enhancement; forward/backward sweep; distributed generation; ant lion optimizer; whale optimize algorithm; particle swarm optimization; economic analysis.**

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