Ain Shams University
Faculty of Engineering
Electrical Power and Machines Department

Enhancement of Voltage Stability and Reactive Power Control using Modern Optimization Methods

A THESIS
Submitted for the Degree of philosophy doctor

In
Electrical Engineering (Power and Machines)

By

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2017

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Agreement Report

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STATEMENT

This dissertation is submitted to Ain Shams University for the degree of philosophy doctor in Electrical Engineering.

The work included in this thesis was carried out by the author of the thesis. No part of this thesis has been submitted for a degree of other university.

Signature

ACKNOWLEDGEMENT

I have the great honor to express my deepest gratitude and sincerest thanks to **Prof. Dr. Almoataz Youssef Abd El Aziz** at Electrical Power & Machines Department, Faculty of Engineering, Ain Shams University, for his kind supervision, guidance and continuous encouragement and for his helpful and fruitful discussions in the preparation of this thesis.

I feel deeply thankful **Prof. Dr. Mahmoud Abd El Hamid** at Electrical Power & Machines Dept, Faculty of Engineering, Ain Shams University, for his useful suggestions and for his kind supervision, guidance discussion and continuous encouragement and for his help.

I would thank **Dr. Mohmed Ezzat Abd El Rahman** at Electrical Power & Machines Dept, Faculty of Engineering, Ain Shams University, for his guidance and unfailing discussions and for every good help until the thesis has been developed.

ABSTRACT

The voltage stability has great effects in power systems planning and operation. Increasing demand for electricity and unmatched expansion in generation and transmission system leads to possible voltage instability problems. The possibility of voltage instability is more probable or severe in a system under emergency, like line outage, than in the system under normal condition. FACTS and distributed generation are considered as good solutions to improve the voltage stability and power loss reduction.

This thesis presents a study of the methods of selecting the size and location of DGs with different penetration level in a distribution network. Also, the impact of using FACTS (i.e. STATCOM and UPFC) is studied. The study depends on different optimization methods such as Genetic Algorithm (GA), Differential Evolution (DE) and Hybrid Big Bang Big Crunch (HBBBC) in order to improve certain objective function which contains the minimization of power loss and improvement of voltage profile and enhancement of voltage stability.

Moreover, the thesis introduces the effect of time varying load model on the voltage stability in the presence of the distributed generation as Photovoltaic is added by using the optimization tools and running Probabilistic Optimal Power Flow (POPF).

A comparison between the different methods applied in this study have been discussed from the results point of view and some important conclusions are extract.
Keywords: Voltage Stability, Optimization methods, HBBBC, DE, GA, STATCOM, UPFC, distributed generation, Photovoltaic.

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LIST OF ABBREVIATIONS

ABC	: Artificial Bee Colony
AVR	: Automatic Voltage Regulator
BBBC	: Big Bang Big Crunch
CSA	: Cuckoo Search Algorithm
DE	: Differential Evolution
DG	: Distributed Generation
FACTS	: Flexible AC Transmission Systems
FFO	: Fire Fly Optimization
FPA	: Flower Pollination Algorithm
GA	: Genetic Algorithm
GSA	: Gravitational Search Algorithm
HBBBC	: Hybrid Big Bang Big Crunch
HV	: High Voltage
HVDC	: High Voltage DC
kVA	: Kilo Volt Ampere
kVAR	: Kilo Volt Ampere Reactive
LQP	: Line Stability Index
MW	: Mega Watt
NRLF	: Newton Raphson Load Flow
NSIHS	: Non-dominated Sorting Improved Harmony Search
OLTC	: On Load Tap Changing
OPF	: Optimal Power Flow
ORPD	: Optimal Reactive Power Dispatch
POPF	: Probabilistic Optimal Power Flow
PV	: Photovoltaic

BBBC : Big Bang Big Crunch

CSA : Cuckoo Search Algorithm

DE : Differential Evolution

DG : Distributed Generation

FACTS : Flexible AC Transmission Systems

FFO : Fire Fly Optimization

FPA : Flower Pollination Algorithm

GA : Genetic Algorithm

GSA : Gravitational Search Algorithm

HBBBC : Hybrid Big Bang Big Crunch

HV : High Voltage

HVDC : High Voltage DC

kVA : Kilo Volt Ampere

kVAR : Kilo Volt Ampere Reactive

MW : Mega Watt

NRLF : Newton Raphson Load Flow

NSIHS : Non-dominated Sorting Improved Harmony Search

OLTC : On Load Tap Changing

OPF : Optimal Power Flow

ORPD : Optimal Reactive Power Dispatch

POPF : Probabilistic Optimal Power Flow

PV : Photovoltaic

SA : Simulated Annealing

SCIG : Squirrel Cage Induction Generator

SSSC : Static Synchronous Series Compensator

STATCOM : Static Synchronous Compensator

TCPAR : Thyristor Controlled Phase Angle Regulator

TCSC	: Thyristor Controlled Series Compensator
TVAC	: Time Varying Acceleration Coefficients
UHV	: Ultra High Voltage
UPFC	: Unified Power Flow Controller
VCPI	: Voltage Collapse Proximity Index
VSC	: Voltage Source Converter

LIST OF SYMBOLS

COSØ	: load power factor
b_{st}	: The admittance of STATCOM
G_K	: The conductance of the line ‘k’
g_{st}	: Conductance of STATCOM
N_L	: Number of transmission lines
N_P	: Size the population of HBBBC
P_D	: Delivered active power to the load
P_{ij} and Q_{ij}	: The real and reactive power flow from bus-i to bus- j
P_{is} , Q_{is}	: Injected active and reactive power of UPFC at bus-i
P_{js} , Q_{js}	: Injected active and reactive power of UPFC at bus- j
P_{PV}	: PV output power (W)
$P_{rated\text{-}PV}$	: The PV rated power (W)
P_{st} , Q_{st}	: Active and reactive power of STATCOM
Q_D	: Delivered reactive power to the load
R	: The solar irradiance (W/m^2)
r, α	: Control variables of HBBBC
R_C	: A certain radiation point
R_{STD}	: The solar irradiance in the standard conditions (W/m^2)
R_T	: Certain percent of the voltage magnitude at bus i
V_1	: Sending end voltage
V_2	: Receiving end voltage
V_i	: Voltage magnitude of bus i
V_j	: Voltage magnitude of bus j
V_p , V_{st}	: Bus voltage and STATCOM voltage
V_T	: Magnitude of injected voltage by UPFC