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ORIGINAL PAPER

Genetic algorithm-based fuzzy multi-objective approach to congestion management using FACTS devices

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Abstract This paper investigates a novel optimization-based methodology for placement of Flexible AC Transmission Systems (FACTS) devices in order to avoid congestion in the transmission lines while increasing static security margin and voltage profile of a given power system. The optimizations are carried out on the basis of location, size, and number of FACTS devices. Thyristor Controlled Series Compensator (TCSC) and Static Var Compensator (SVC) are two FACTS devices which are implemented in this investigation to achieve the determined objectives. The problem is formulated according to Sequential Quadratic Programming (SQP) problem in the first stage to accurately evaluate static security margin with congestion alleviation constraint in the presence of FACTS devices and estimated annual load profile. In the next stage a Genetic Algorithm (GA)-based fuzzy multi-objective optimization approach is used to find the best trade-off between conflicting objectives. The IEEE 14-bus test system is selected to validate the proposed approach.

Keywords Voltage stability · Congestion management · FACTS · Optimal location · Genetic algorithm · Fuzzy

List of symbols

$B_{\mathrm{SVC}j}$	susceptance of jth SVC in (pu)
β_i	per unit value representing the relative increase in the load at bus i
α	Positive scalar variable
γ_i	participation factor of ith generator
dv_i	maximum voltage violation tolerance (%)
f_1, f_2, f_3	problem objective functions
$f_i^{\mathrm{ini}}, f_i^{\mathrm{obj}}$	unaccepted and desired level for each objective function
F	fuzzy performance index
J_L	a set contains all load buses
J_c	set of voltage controlled buses
J	Jacobian matrix
l_i	ith line number
M	number of load buses
N	number of buses
N_{FACTS}	number of FACTS devices
n_t	number of LTC transformers
$P_{\mathrm{inj}f}^{\mathrm{TCSC}}, Q_{\mathrm{inj}f}^{\mathrm{TCSC}}$	injected active and reactive power at bus f in (pu)
$P_{\mathrm{inj}t}^{\mathrm{TCSC}}, Q_{\mathrm{inj}t}^{TCSC}$	injected active and reactive power at bus t in (pu)
P_i	real power entering bus i in (pu)
P_D	total system demand in (pu)
$P_i^{\max}$	maximum active power limits of generating unit i in (pu)
$P_i^{\min}$	minimum active power limits of generating unit i in (pu)
$P_{l_i}^{\max}$	maximum active power limit of line l_i in (pu)
$P_{l_i}^{\min}$	minimum active power limit of line l_i in (pu)
P_0, Q_0	prescribed real and reactive loads at rated (normal) voltage in (pu)
p_f, q_f, p_t, q_t	constants that reflect the load-voltage characteristics at buses f and t
P_m	mutation rate $\in$[0,1]
Q_i	reactive power entering bus i in (pu)

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