ISSN (Online) : 2454-4159
IJARSMT
International Journal of Advanced Research in Science Management and Technology
Volume 3, Issue 1, January 2017

Power System Stability Enhancement Using Optimal Placement of TCSC via Genetic Algorithm

Prajuj Patil[1] , Alka Thakur[2]
PG Student, Dept. of Electrical Engineering, SSSIST, Sehore , M.P.,India[1]
Ass. Professor, Dept. of Electrical Engineering, SSSIST, Sehore ,M.P.,India[2]

ABSTRACT- This paper presents an approach to find the optimal location of thyristor-controlled series compensators (TCSC) in a power system to improve the loadability of its lines and minimize its total loss. Also the proposed approach aims to find the optimal number of devices and their optimal ratings by using genetic algorithm (GA) with taking into consideration the thermal and voltage limits. Examination of the proposed approach is carried out on the IEEE 6-bus , 14 bus and 30 bus system.

KEYWORDS- TCSC devices, Genetic algorithms, Optimal locations, Loss minimization.

I. INTRODUCTION

Deregulated power systems suffer from congestion management problems. Also they cannot fully utilize transmission lines due to excessive power loss that it could cause. FACTS devices such as thyristor-controlled series compensators (TCSC) can, by controlling the power flow in the network, help reducing the flows in heavily loaded lines. Also they can minimize the power loss of the systems. However, because of the considerable cost of FACTS devices, it is important to minimize their number and obtain their optimal locations in the system. The TCSC is one of the series FACTS devices. It uses an extremely simple main circuit. In this FACTS device a capacitor is inserted directly in series with the transmission line to be compensated and a thyristor-controlled inductor is connected directly in parallel with the capacitor, thus no interfacing equipment, like high voltage transformers, are required. This makes the TCSC much more economic than some other competing FACTS technologies [1]. In [2], the TCSC may have one of the two possible characteristics: capacitive or inductive, respectively to decrease or increase the overall reactance of the line XL. It is modeled with three ideal switched elements connected in parallel: a capacitor, an inductor and a simple switch to shortcircuit both of them when they are not needed in the circuit. The capacitor and the inductor are variable and their values are dependent on the reactance and power transfer capability of the line in series with which the device is inserted. In order to avoid resonance, only one of the three elements can be switched at a time. Moreover, in order to avoid overcompensation of the line, the maximum value of the capacitance is fixed at -0.8 XL. For the inductance, the maximum is 0.2 XL.The TCSC model presented in [2] is shown in Fig. 1.

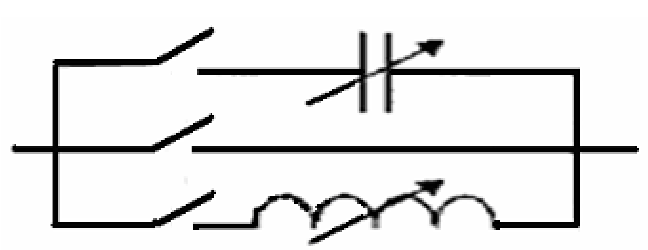

Fig. 1 Model of the TCSC [2]

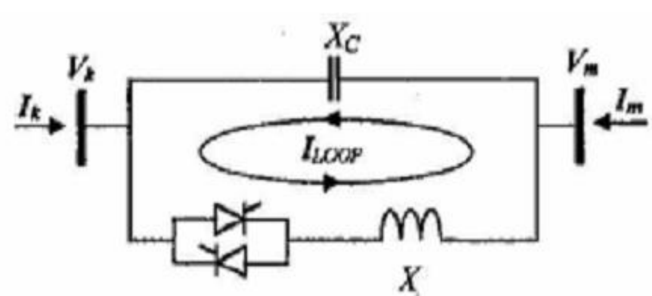

Fig. 2 Model of the TCSC [3]

In [3], the TCSC is a capacitive reactance compensator which consists of a series capacitor bank shunted by a thyristorcontrolled reactor to provide a smooth control of the series capacitive reactance. Model of the TCSC presented in [3] is shown in Fig. 2. Another TCSC model has been used in [4]. According to this model a variable reactance is inserted in series with the line to be compensated. This model is used in this paper and the reactance is assumed to vary in the range from -0.3 XL to -0.7 XL. Several research works are carried out to solve the optimal location problem of the TCSC. Optimization techniques applied in most of these works cannot be accepted as general optimization techniques as they used a fixed pre-specified number of FACTS devices. Some other works did not select the proper type or the proper working range of FACTS devices used in the optimization problem.Power system can, in general, be measured by system loadability and/or system losses at a condition that nodal voltage magnitudes are kept within acceptable limits and thermal constraints of system elements are not violated.According to [2] such optimization problem can be solved by using heuristic methods such as genetic algorithms [5, 6]. T. S. Chung et al. [7] applied a hybrid Genetic Algorithm (GA) method to solve OPF incorporating FACTS devices. GA is integrated with conventional optimal power flow (OPF) to select the best control parameters to minimize the total generation fuel cost and keep the power flows within the security limits.

L. Cai et al. [8] proposed optimal choice and allocation ofFACTS devices in multi-machine power systems using genetic algorithm. The objective is to achieve the power system economic generation allocation and dispatch in a deregulated electricity market. In [9], implementation of the proposed real genetic algorithm has performed well when it is used to determine the location and compensation level of TCSC with the aim of maximizing the Total Transfer Capability (TTC) of the system. M. Saravanan et al. [4] proposed the application of PSO to find the optimal location, settings, type and number of FACTS devices to minimize their cost of installation and to improve system loadability for single- and multi-type FACTS devices. While finding the optimal location, the thermal limit for the lines and voltage limit for the buses are taken as constraints. In [10], FACTS devices are optimally allocated in a power network to achieve (OPF) solution.

The location of FACTS devices and the setting of their control parameters are optimized by a Bacterial Swarming Algorithm (BSA) to improve the performance of the power network. Two objective functions are simultaneously considered as the indices of the system performance: maximization of system loadability in system security margin and minimization of total generation fuel cost. In this paper, an approach to find the optimal location of thyristor-controlled series compensator (TCSC) in the power system to improve the loadability of the lines and minimize the total loss using GA is presented. The proposed approach aims to find the optimal number of devices and their optimal ratings with taking into consideration the thermal and voltage limits. Examination of the proposed approach is carried out on IEEE 9-bus system.

II. THE PROPOSED OPTIMIZATION TECHNIQUE

The problem is to find the optimum numbers, locations and reactance's of the TCSC devices to be used in the power system. This problem is a nonlinear multi-objective one. The GA method will be used in this paper where it only uses the values of the objective function and less likely to get trapped at a local optimum. As shown in the flow chart given in Fig. 3, the selected method is to use two genetic algorithms with number of generations of 30, fitness limit

ISSN (Online) : 2454-4159
International Journal of Advanced Research in Science Management and Technology
Volume 3, Issue 1, January 2017

of zero and the other parameters are taken as the default values in MATLAB. The first one is to find the location and number of TCSC devices by computing the minimum total loss after inserting TCSC in the system. After location and number of TCSC are obtained they have been given to another genetic algorithm to obtain the best rating of TCSC by also computing the total loss. Two optimization techniques using GA are used to solve the TCSC optimal location problem.

• **First technique-** In the first technique the objective is to minimize the total losses without taking into consideration limitations on the number of devices, i.e. it is required to minimize the objective function:

Total system losses = Sum of real loss of all system lines (1)

• **Second technique-** Same as the first technique, but the number of devices is considered, i.e. it is required to minimize the objective function:

(Total system losses after applying the TCSCs) / (Total system losses before applying the TCSCs) + (Number of TCSC devices/Total number of locations available for connecting the TCSCs) (2)

Calculation of total loss is obtained by using Matlab m-files Matpower [11] to calculate the power flow of the system and compute the sum of real losses.In this paper the reactance of each branch in Matpower case is replaced by variable reactance function of the value of TCSC reactance added as in equation (3).

New reactance = Old reactance + X TCSC (3)   Fig. 3 shows the flow chart of the selected technique.

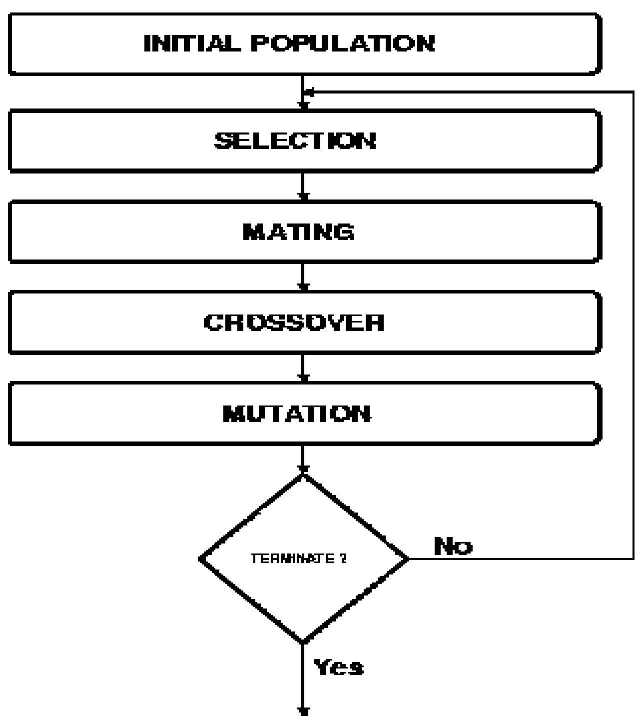

Fig. 3 Basic Flow chart for Genetic Algorithm

ISSN (Online) : 2454-4159
International Journal of Advanced Research in Science Management and Technology
IJARSMT
Volume 3, Issue 1, January 2017

III. PROPOSED SYSTEM

Here we have proposed a network reconfiguration using genetic algorithm. The system works as follows, instead of configuring only switching in the entire distribution network the system instead changes the position of various busses in the system while at the same time maintain the radiality of the system.Consider for example a six bus system as shown below:-

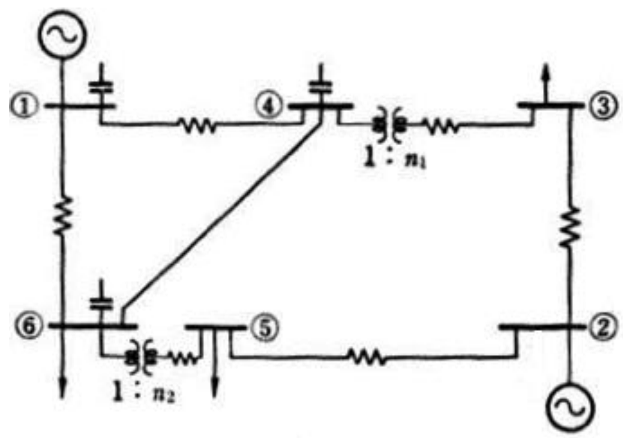

Fig.4 IEEE 6 Bus System

Now in this particular system, earlier research work has been focused on changing position of network switches to improve the efficiency of the system and to reduce the power loss. Our work has been focusing on changing the iteration of buses on the line such that Radiality is maintained and then calculating the power loss. This has been accomplished using genetic algorithm and the optimum function the power loss for a given configuration.

A complete graphical user interface has been created that has been shown in the figure given below:-

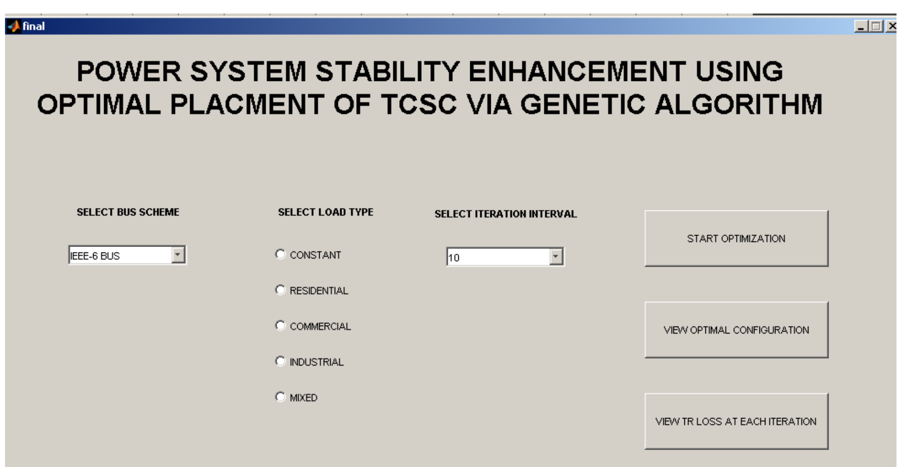

Fig. 5 GUI for the proposed system

Now in the above proposed GUI, it has been given the following provisions for the user to select:-

1) Selecting the appropriate bus system for the network under test. The options available for the user are 6 bus, 14 bus, 30 buses and 54 bus system respectively.
2) The user can also select the load type for the network under test. The available load types are constant load, commercial load, industrial load, domestic load and mixed load.
3) After selecting the above parameters the GUI opts the user to select the number of iterations after which the genetic algorithm should start converging. Depending on the bus type and computation power available, tothe user can select the appropriate iteration. Usually it turns out that the larger the number of iteration more optimum is the result.
4) Then finally the GUI has button action group for selecting the optimization start function, graph viewing and finally seeing the optimum configuration after the genetic algorithm has been deployed for the system.

Below is the result for all the systems one by one:-

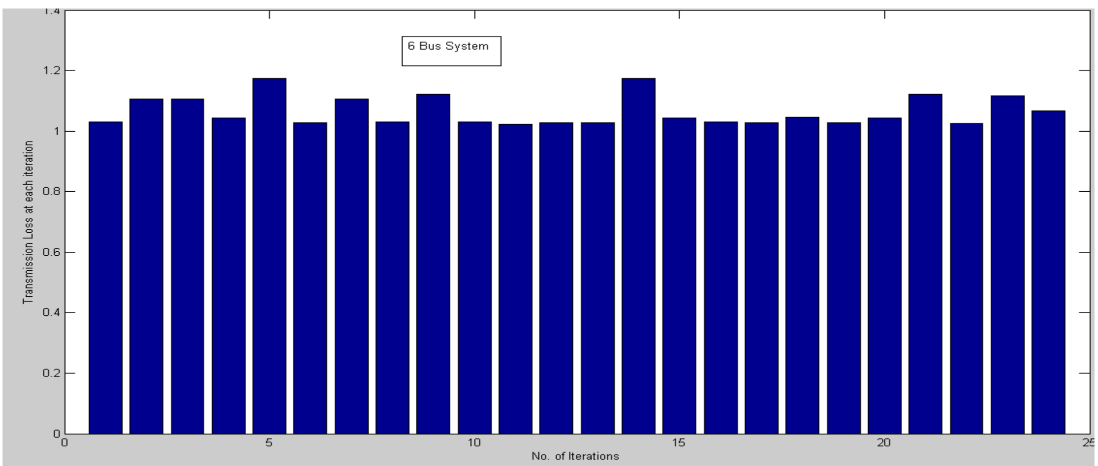

Fig. 6 Graph Showing Transmission loss at each iterations taking no of iteration = 30 for a six bus system

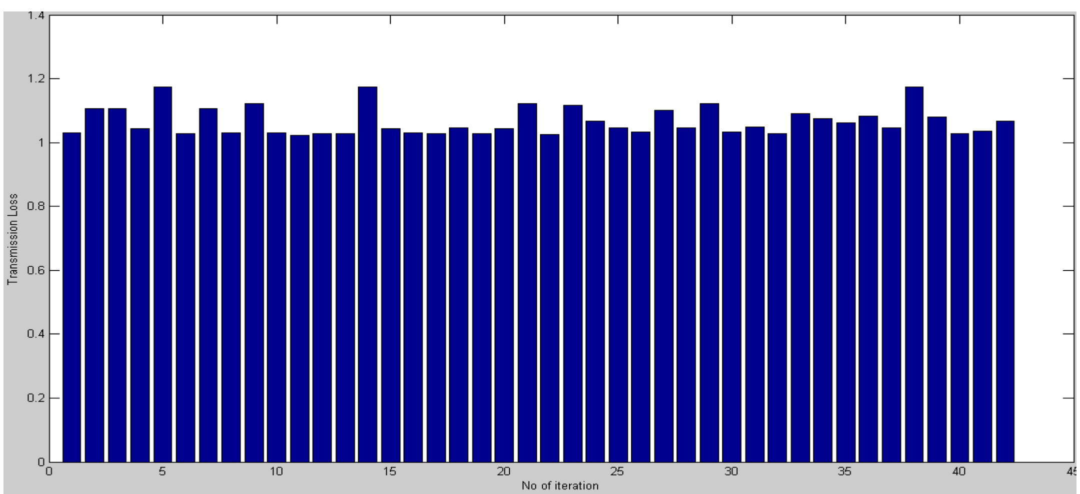

Fig. 7 Graph Showing Transmission loss at each iterations taking no of iteration = 50 for a six bus system

ISSN (Online) : 2454-4159
International Journal of Advanced Research in Science Management and Technology
Volume 3, Issue 1, January 2017

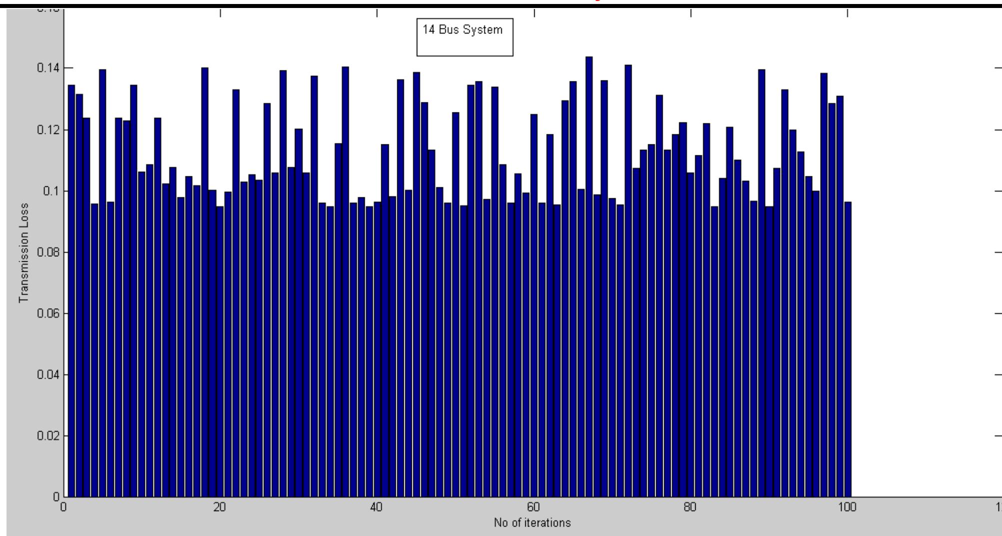

Fig. 8 Graph Showing Transmission loss at each iterations taking no of iteration = 100 for a fourteen bus system

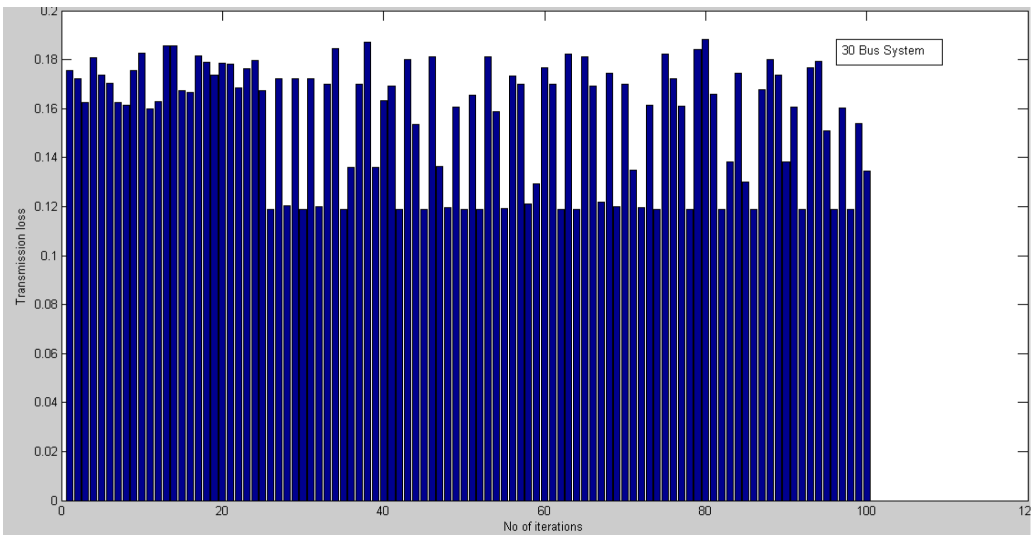

Fig. 9 Graph Showing Transmission loss at each iterations taking no of iteration = 100 for a thirty bus system

IV. CONCLUSION

From the simulation results performed using Matlab 7.12, it is quite clear that this approach is better than the earlier work done in this field. But the primary drawback for the said system is that for computing permutations and applying genetic approach for a large bus systems such as 30 and 54, it becomes increasingly difficult for a normal machine and hence the computational requirements levied on the software is much greater than it was expected.

REFERENCES

[1] **H. W. Dommel and W. F. Tinny, "Optimal power flow solutions," IEEE trans. on power app &systems, 87, 1968, pp 1866-1876.**

[2] **K. Y. Lee, Y. M. Park, and J. L. Ortiz, "A united approach to optimal real and reactive power dispatch," IEEE trans. on PAS, 104, 1985, pp. 1147-1153.**

[3] G. R. M. Da Costa, "Optimal reactive dispatch through primal-dual method," IEEE trans. on power systems, Vol. 12, No. 2, May 1997, pp 669-674.

[4] L. D. B. Terra and M. J. Short "Security constrained reactive power dispatch," IEEE Trans. on power systems, Vol. 6, No. 1, February 1991.

[5] K. H. A. Rahman and S. M. Shahidehpour, "Application of fuzzy set theory to optimal reactive power planning with security constraints," IEEE Trans. on power systems, Vol. 9, No.2, May 1994, pp. 589-597.

[6] K. Iba, "Reactive power optimization by genetic algorithm," IEEE trans. on power systems, Vol. 9 No. 2, 1994, pp 685-692.

[7] ShahabMehraeen, SarangapaniJagannathan and Mariesa L. Crow, "Power System Stabilization Using Adaptive Neural Network-Based Dynamic Surface Control", IEEE Transactions on Power Systems, 2010.

[8] Yoshitaka Miyazato, TomonobuSenjyu, Ryo Kuninaka, Naomitsu Urasaki, Toshihisa Funabashi and HideomiSekine, "Multi-Machine Power System Stabilization Control by Robust Decentralized Controller Based on Optimal Sequential Design", PSCE, 2006.

[9] Vournas C.D, Papadias B.C, "Power System Stabilization via Parameter Optimization - Application to the Hellenic Interconnected System", IEEE Transactions on Power Systems, Vol. 2, No. 3, 2007.

[10] Soon Kiat Yee, Milanovic J.V, "Fuzzy Logic Controller for Decentralized Stabilization of Multimachine Power Systems", IEEE Transactions on Fuzzy Systems, Vol. 16, No.4, Pp. 971-981, 2008.

[11] Yagami M, Tamura J, "Power System Stabilization by Fault Current Limiter and Thyristor Controlled Braking Resistor", IEEE Energy Conversion Congress and Exposition (ECCE), Vol. 1, Pp. 335 – 338, 2009.

[12] LiZhengguo, Yang Guanghong, Wen Changyun, XieWenxiang, "Stabilization of Power Systems by Switched Controllers", Chinese Control Conference (CCC), Pp. 756-760, 2007.

[13] A. Merlin, and G. Back, "Search for minimum-loss operational spanning tree configuration for an urban power distribution system," in Proc. Fifth Power System Conf. (PSCC), Cambridge, U.K., 1975, pp. 1–18.

[14] D. Shirmohammadi, and H.W. Hong, "Reconfiguration of electric distribution networks for resistive line losses reduction," IEEE Trans. Power Del., vol. 4, no. 2, pp. 1492–1498, April 1989.

[15] S. Civanlar, J. Grainger, H. Yin, and S. Lee, "Distribution feeder reconfiguration for loss reduction," IEEE Trans. Power Del., vol. 3, no. 3, pp. 1217–1223, July 1988.

[16] M. E. Baran and F.Wu, "Network reconfiguration in distribution system for loss reduction and load balancing," IEEE Trans. Power Del., vol. 4, no. 2, pp. 1401–1407, April 1989.

[17] S. Goswami and S. Basu, "A new for the reconfiguration of distribution feeders for loss minimization," IEEE Trans. Power Del., vol. 7, no. 3, pp. 1484–1491, July 1992.

[18] K. Nara, A. Shiose, M. Kitagawa, and T. Ishihara, "Implementation of genetic algorithm for distribution systems loss minimum re-configuration," IEEE Trans. Power Syst., vol. 7, no. 3, pp. 1044–1051, August 1992.