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Optimal sizing and Placement of Capacitors for Loss Minimization In 33-Bus Radial Distribution System Using Genetic Algorithm in MATLAB Environment

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Abstract— **The problem of voltage deviation and power loss is mostly addressed in distribution system by growing domestic, industrial and commercial load day by day. To minimize these problems effective planning of distribution system is required. This effective and reliable planning of distribution system is achieved by Optimized placement of control device (capacitor) in distribution networks. The idea for optimal capacitor placement is to determine the location of capacitor to be installed in the distribution network buses where power losses should be minimum and cost saving should be maximum. This paper presents a novel technique (Tabu search) to determine the optimal location for placement of capacitors in distribution system. In this paper first we find optimal location by Tabu search and after this we placed the capacitor and compare the power loss cost, voltage levels at different buses after and before placement of capacitors.**

Index Terms— **Radial distribution system, optimal location, capacitor placement, genetic algorithm, objective function, power loss**.

I. Introduction

As the electrical loads are increases, the voltage levels at buses collapse down and power loss is also increased. At the higher load demand the lines current become increase which leading to the increase of losses and this also decreases the voltage level in the distribution network. In the distribution system voltage levels at buses related voltage stability and it is determine by load flow solution. By the load flow analysis we calculate voltage level at buses and power flow in the networks [1].

In distribution system to improve the voltage regulation we required to minimize reactive power flow through the system. To overcome these difficulties we place the capacitor in distribution system. The placement of capacitors in radial distribution systems is also provide power flow control, improving system stability, power factor correction, voltage profile management and losses minimization [2]. The problem associate with capacitor placement is the determine the location of capacitors where power loss minimum and cost saving maximum therefore it is important to find the optimal size and location of capacitors. A number of methods have been proposed to solve capacitors placement problem. Like as combinatorial optimization techniques of genetic algorithm, simulated annealing have been applied to find the desirable and almost global optimal solution for capacitors placement problems [3].

This paper proposes a computationally very efficient methodology (Tabu Search) for an optimal location and sizing of capacitors in radial distribution networks. The optimization problem has been formulated as the maximization of the total savings by minimizing the objective function. By this approach the reduction in energy losses is performed, subject to the whole constraint, set of the minimum and maximum voltage limit at buses, set of the optimal reactive power flow, the reactive power balance in each node of the network, and the constraints of selecting for each node only one among the various proposed capacitors banks sizes. The cost of capacitors includes the cost of investment, operation and maintenance [4].

In this paper we have applied the TS method to solve the capacitor placement problem. Problem description of the capacitors placement is first described the objective function. After this we presented the basic scheme of the TS method and its applications to minimize the objective

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function and determine optimal location of capacitors where it will be placed at different buses. and in last we present the numerical results of the TS method, which tested in a 33-bus radial distribution system [5,6].

II. System Disccription

We take IEEE 33-bus system to placed capacitors at optimal location which find out by TS optimization method. The system has 4 feeders which supply to 33 load centers. The system has 12.66KV as a base voltage and 150MVA as a base MVA [7].

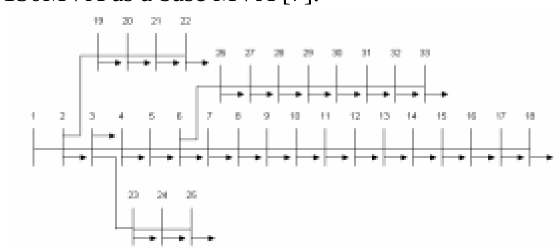

Figure1. One line diagram of IEEE 33-bus radial distribution

III. Problem Formulations

The objective is aimed to reduce the energy losses in the system and maintain the voltage magnitudes of the system within prescribed maximum and minimum allowable values for different load levels while minimizing the total cost of the system. Power flow evaluation in the system includes the calculation of bus voltages and line flows of a network. A single-phase representation is adequate because power systems are usually balanced. Associated with each bus, there are four quantities to be determined or specified: the real and reactive powers, the voltage magnitude and phase angle. The objective function of the problem can be expressed as follows to minimize the capacitor investment cost and system energy loss [8,9]:

$$Min\{K_c \sum_{i=1}^{L} Q_{ci} + K_e \sum_{i=1}^{b} P_{lossi}\}$$

Subjected to $V_i^{min} \leq V_i \leq V_i^{max}$ (voltage constraints)
Where
Q_c is size of capacitor in KVAR, P_{lossi} is the power loss in the i^{th} branch, L is the length of capacitors size array, b is the total number of branch, Ke is the Energy Cost (Rs./Kwh), Kc is the capacitor cost(Rs./Kvar). V_i is voltage magnitude of node i, Vi^{min} and Vi^{max} are the minimum and maximum voltage limits of node i respectively.

Figure 2. Shows the power flow diagram of radial distribution system. In which voltage at the buses and power inject to each branch is calculated is determine by gauss sadial load flow method [10].

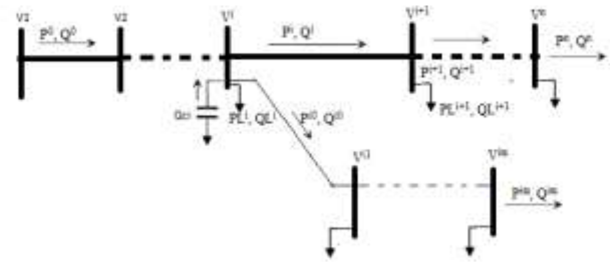

Figure 2. load flow analysis diagram of a radial distribution

The voltage magnitude at node, power flow in the branches, power losses in the branches is determine by g at i^{th} bus is determine by according to guass sediel
The power loss in each branch is given by:

$$P_{loss(i,i+1)} = R_{i,i+1}[(V_{i,i+1} - V_i) * Y_{i,i+1}]^2$$

total power loss of the system is given by:

$$P_{loss} = \sum_{i=1}^{m} P_{loss(i,\, i+1)}$$

Where m is the total no. of buses

IV. Solution Methodology

Genetic Algorithm Control Scheme

The genetic algorithm is a global search technique for solving optimization problems, which is based on the theory of natural selection, the process that drives biological evolution.

Genetic Algorithm has proved to be a very effective and efficient tool for operation and control of power system. Among the various application schemes GA based control scheme has played a significant role in AGC. Better capability of stochastic heuristic search and ease of convergence make GA an obvious choice to solve this optimization [14]-[15]. It has been found to be the right choice for achieving global optimum values of the gain.

Steps involved determining the optimal parameters of the controller using genetic algorithm are given below.

I. Start: Create random population of n chromosomes
II. Fitness: Evaluate fitness of each chromos in the population
III. New population:
a. Selection: Based on fitness function
b. Recombination: Cross-over chromosomes
c. Mutation: Mutate chromosomes
d. Acceptation: reject or accept new one
IV. Replace: old with new population and the new generation
V. Test: Test for problem criterion
VI. Loop: Continue step II-V until criterion is satisfied

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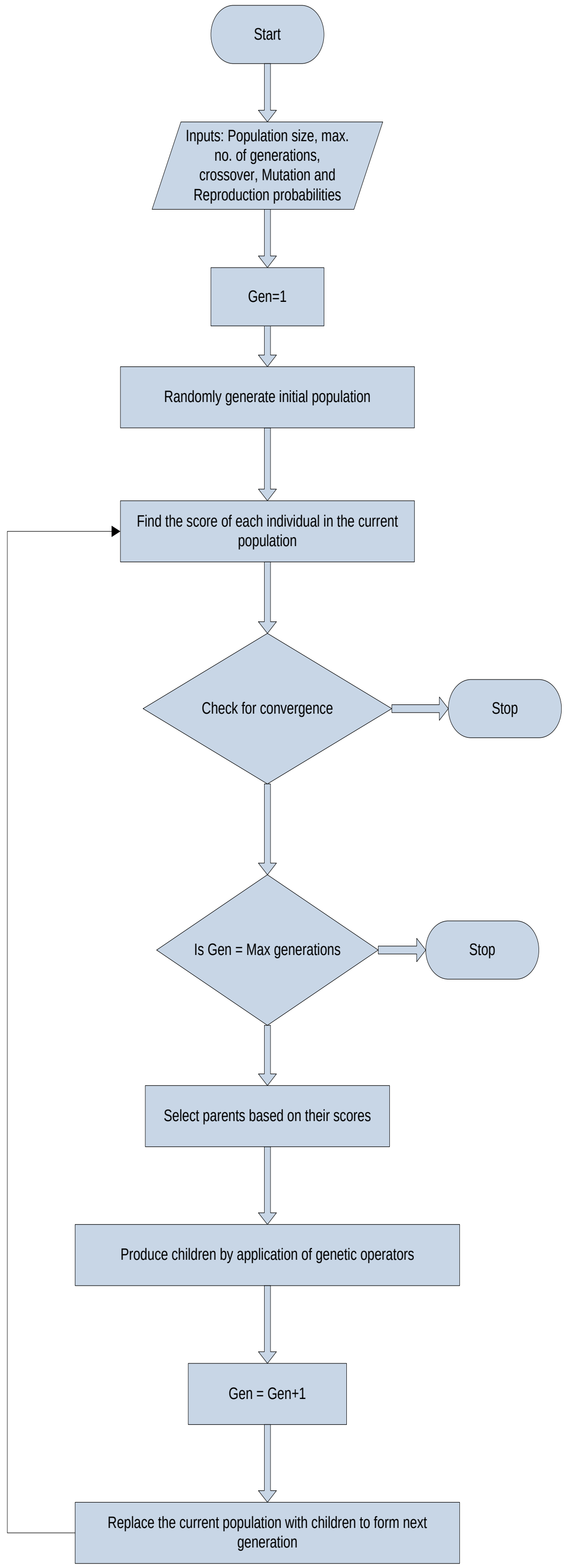

Fig. 3.1 Flow chart of Genetic Algorithm

A) Solution algorithm for capacitor placement

Solution method for capacitor placement problem by TS is determining the location of capacitors. The solution methodology is given by following step[14]-

1) *Step1-Read system datas (Busdatas and Linedatas).*
2) *Step2 – Calculate Ybus and perform load flow analysis and find out the voltage magnitude and power flow in branches.*
3) *Step3- perform TS*
   Initialize Tabu list , Tabu size and initial solution. And find optimal location of capacitor placements.

Step4- Place the capacitor at appropriate location which determine in previous.

Step5- Perform load flow analysis and compare result before and after placement of capacitors.

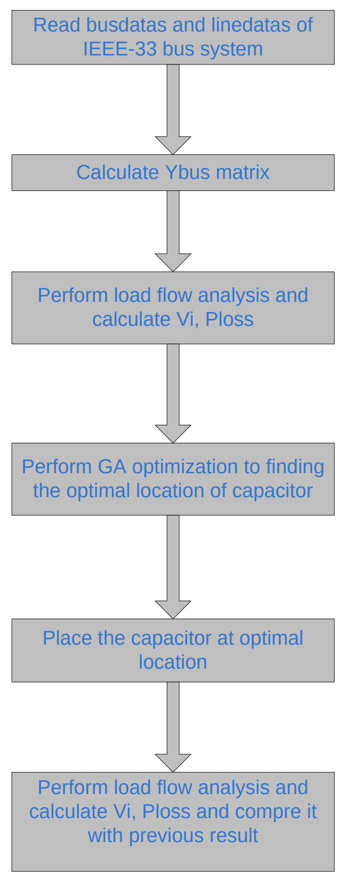

Figure 4. genetic flowchart of solution algorithm for capacitor placement

V. RESULT

The test system is a 33-node radial distribution system which includes one main feeder and three laterals as shown in Figure 1.

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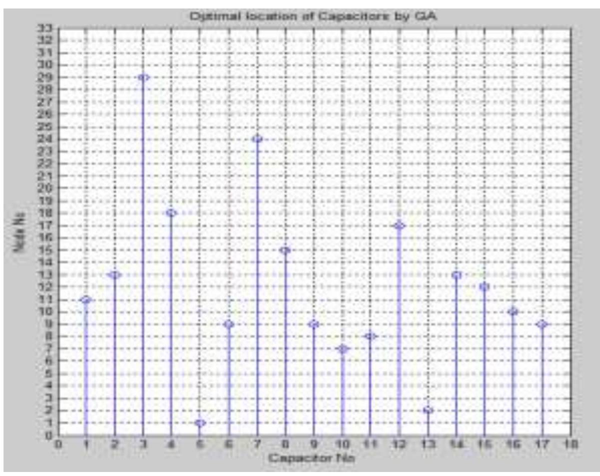
A) Case 1: without capacitors placement

In this case voltage at the buses violated between 1p.u. to 0.7283p.u.which is not in prescribed sustainable min. limit. Total power loss in the system is 133.95MW. Total energy loss cost is K_e*Ploss*time. Therefore total energy loss cost of the system is 401850 Rs/hour

B) Case 2 - placement of capacitors at optimal locations which determine by GA

We placed seventeen capacitors with rating [10, 12, 15, 17, 20, 23, 25, 28, 30, 32, 35, 38, 40, 42, 45, 48, 50] Kvar at bus no [33, 12, 14, 16, 18, 21, 20, 19, 3, 9, 10, 6, 8, 7, 5, 4, 2] respectively. By placing the capacitors, minimum voltage at bus 18,is improved from 0.7283 to 0.9325. Total power loss in the system is 82.95MW, and Total energy loss cost is 248850 Rs/hour. Cost of capacitors is calculated by Kc*Qc and it is 102200Rs Total cost saving is given by, energy loss cost without capacitor-(energy loss cost with capacitor+ capacitor cost). So total cost saving is 50800Rs.



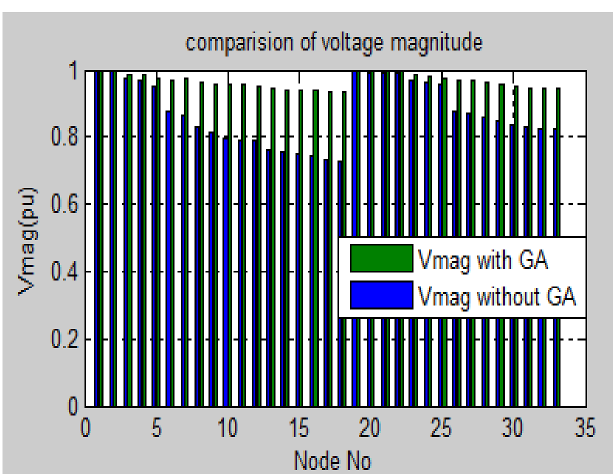


Figure 5. Comparison of voltage magnitude with and without GA

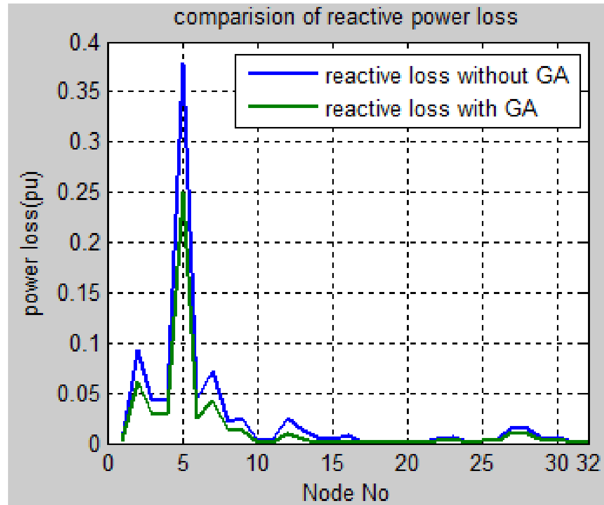


Figure 6. Comparison of reactive power loss with and without GA

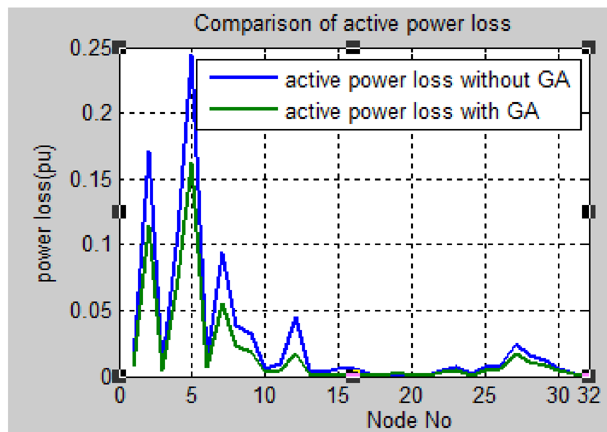


Figure 7. Comparison of active power loss with and without GA

TABLE I. VOLTAGE MAGNITUDE AND POWER LOSS IN BRANCH WITH AND WIITHOUT CAPACITOR PLACEMENT

Node No	Vmag(p.u.) without C	Vmag with C	Ploss(p.u.) without C	Ploss with C
1	1	1	0.0112	0.0079
2	0.998774	0.99919	0.1943	0.1308
3	0.973802	0.986095	0.0449	0.0306
4	0.968703	0.987957	0.1174	0.08
5	0.949697	0.977179	0.4499	0.2956
6	0.878295	0.971055	0.0461	0.0248
7	0.867213	0.973177	0.1188	0.0652
8	0.828625	0.962372	0.0443	0.0245
9	0.811664	0.956814	0.0413	0.0213
10	0.794257	0.952987	0.006	0.0027
11	0.791779	0.951832	0.0101	0.0041
12	0.787361	0.9497	0.0513	0.0187
13	0.761298	0.939608	0.0139	0.0044

14	0.753865	0.939433	0.0067	0.0018
15	0.749017	0.939003	0.0069	0.0017
16	0.743002	0.937012	0.0104	0.0014
17	0.73146	0.933805	0.002	0.0003
18	0.728455	0.932547	0.0008	0.0009
19	0.99774	0.999101	0.0033	0.0048
20	0.991573	0.999025	0.0004	0.0009
21	0.990449	0.999312	0.0001	0.0004
22	0.989694	0.999849	0.0059	0.0039
23	0.969418	0.983096	0.0089	0.0059
24	0.961655	0.977485	0.0024	0.0016
25	0.957517	0.974627	0.0072	0.0057
26	0.875191	0.96952	0.0088	0.0066
27	0.871118	0.967417	0.0298	0.021
28	0.85644	0.960151	0.0218	0.0147
29	0.845116	0.955315	0.0127	0.0086
30	0.836873	0.949625	0.0089	0.0056
31	0.828582	0.946685	0.0026	0.0015
32	0.825205	0.944835	0.0003	0.0002
33	0.824041	0.94526		

TABLE II. RESULT ANALYSIS OF THE SYSTEM WITH AND WITHOUT CAPACITOR PLACEMENT

	Without Capacitor	**With Capacitor by GA**
Power Loss	193.44MW	121.26
Minimum voltage (p.u.)	0.7285	0.9353
Maximum deviation of bus voltage (p.u.)	0.2715	0.0647
Power Loss Cost(Rs)	580310Rs	363800
Capacitor Cost(Rs)	-	102200
Cost saving(Rs)		114310Rs

VI. CONCLUSIONS

This paper has proposed and successful applied Tabu search global optimization method for determine optimal location for capacitor placement in 33-bus radial distribution systems for minimum value of objective function. In this paper by making a objective function and solving by TS optimization, Power losses and power loss cost are reduced by placement of capacitors. By capacitor placement the voltage level reached in allowable range. So optimal capacitors placement is a grateful method to reduce power losses in the system.

REFERENCES

[1] T. Gozel, U.Eminoglu"A tool for voltage stability and opyimization in radial distribution system using matlab GUI " simulation modelling practice and theory 16(2008)505-518,Science Direct

[2] Brian W. Coughlan, David L. Lubkeman, John Sutton" improved control of capacitor bank switching to minimize distribution systems losses" 1990 IEEE

[3] A. Lakshmi devi and b. subramanyam" optimal dg unit placement for loss reduction in radial distribution system-a case study" arpn journal of engineering and applied sciences vol. 2, no. 6, december 2007

[4]Hong-Chan Chin,"Optimal shunt capacitor allocation by fuzzy dynamic programming,"Electric Power System Research 35 1995, pp.133-139.

[5] D.Richardson, "Identification of Capacitor Position in a Radial System," IEEE Transactions on Power Delivery, Vol.14, No.4 October 1999,pp1368-1373.

[6]M.M.A Salama, A.Y.Chikhani., "Classification of Capacitor Allocation Techniques," IEEE Transactions on Power Delivery, Vol.15, No.1 ,January 2000,pp387-392.

[7] J.C.Carlisle, A.A.El-Keib, "A Graph Search Algorithm for Optimal Placement of Fixed and Switched Capacitors on radial Distribution Systems ," IEEE Transactions on Power Delivery, Vol.15, No.1 ,January 2000,pp423-428.

[8] Y. Baghzouz" Effects of nonlinear loads on optimal capacitor placement in radial feeders" IEEE Transactions on Power Delivery, Vol. 6, No. 1, January 1991

[9]S. M. Hakimi, M. Zarringhalami, S. M. Moghaddas Tafreshi " Optimal Capacitor Placement and Sizing in Non-Radial Distribution to Improve Power Quality" 978-1-4244-7245-1/10/ ©2010 IEEE.

[10]Hong-Tzer Yang , Yam-Chang Huang Ching-Lien Huang:" Solution to Capacitor Placement Problem in a Radial Distribution System Using Tabu Search Method" IEEE Catalogue No. 95TH8130 0-7803-2981 -3/95/$4.00O1995 IEEE

[11] F. Glover, M. Laguna, Tabu Search, Kluwer Academic Pubs., 1997.

[12] Tama-ku, Kawasaki 214-8571" Capacitor Placement Using Parallel Tabu Search in Distribution Systems" 0-7803-5731-0/99/$10.00 01999 IEEE

[13] Wassim Jaziri" Local Search Techniques:Focus on Tabu Search" Published by In-The in September 2008

[14]Mrs. Asha Gaikwad, Dr. Rakesh Ranjan, Dr. L. D. Arya" Capacitor Placement for Loss Reduction of Reconfigured Radial Distribution Systems by Depth First Search Algorithm" Published in International Journal of Advanced Engineering & Applications, Jan. 2010

Appendix A

Busdatas of IEEE 33-bus system				Linedatas of IEEE 33-bus system			
Bus no	**V(P.U.)**	**PL(MW)**	**QL(MVAR)**	**From Bus**	**To bus**	**R(p.u.)**	**X(p.u.)**
1	1.0000	0	0	1	2	0.8021	0.0567
2	0.9558	100	100	2	3	0.4289	0.2335
3	.9271	180	80	3	4	0.0259	0.1734
4	0.9210	140	160	4	5	0.4569	0.1805
5	0.9008	120	60	5	6	1.0713	1.6575
6	0.8191	120	40	6	7	0.1629	0.5755
7	0.8098	200	200	7	8	1.4889	1.1486
8	0.7750	400	200	8	9	0.8961	0.4862
9	0.7598	120	40	9	10	0.8735	0.6752
10	0.7443	120	40	10	11	0.1710	0.0604
11	0.7420	90	60	11	12	0.3257	0.1151
12	0.7380	140	120	12	13	1.8973	1.0252
13	0.7152	120	70	13	14	0.2452	0.6630
14	0.7098	240	160	14	15	0.2564	0.4892
15	0.7064	120	120	15	16	0.6493	0.5069
16	0.7020	220	200	16	17	1.1214	1.6005
17	0.6972	120	40	17	18	0.6368	0.5338
18	0.6958	180	80	17	18	0.6368	0.5338
19	0.9549	180	80	2	19	0.1427	0.1455
20	0.9492	120	60	19	20	1.3087	1.2605
21	0.9479	180	80	20	21	0.3686	0.4449
22	0.9469	140	90	21	22	0.6167	0.8569
23	0.9207	180	100	3	23	0.3925	0.2867
24	0.9089	750	320	23	24	0.7813	0.6595
25	0.9021	840	400	24	25	0.7795	0.7856
26	0.8150	120	50	6	26	0.1766	0.0962
27	0.8096	120	50	26	27	0.2473	0.1346
28	0.7889	120	40	27	28	0.9213	0.5869
29	0.7709	240	1400	28	29	0.6997	0.6516
30	0.7626	400	120	29	30	0.7854	0.2404
31	0.7544	200	100	30	31	0.8695	0.8956
32	0.7511	420	200	31	32	0.5689	0.3366
33	0.7505	120	80	32	33	0.2567	0.5690