International Journal of Engineering and Advanced Technology (IJEAT)
ISSN: 2249-8958 (Online), Volume-8 Issue-5, June 2019

A Penalty based Self Adaptive Harmony Search Algorithm for Optimal Load Shedding

Raghu C N, A. Manjunatha, G Raghavendra

Abstract*: *In this paper, a novel method is introduced to avoid the blackout of a power system when there is a loss of generation. A new load shed scheme is introduced with the priority based choice to decide the amount of load to be shed at each bus in the system. The priorities are assigned based on the voltage drop after the generation loss. The priority assigned, an improved self adaptive harmony search algorithm (ISAHS) is triggered to determine the optimal amounts of the load to be shed. The MATPOWER solver is used to solve the power flow equation. The simulations are conducted and the performance of the proposed method is analyzed on IEEE-14. In IEEE-14 bus system total active and reactive power shedding is 193.47MW and 51.89MVAR respectively which are less than the existing methods. The amount of load shedding obtained using proposed method gives better results compared to the existing. The range of bus voltage swing achieved in IEEE-14 is 1.01pu to 1.062pu. The active and reactive power supplied before and after the generation loss, is computed for each case. The losses incurred in the bus system are also computed. The improvement in the bus voltages is presented after designing the new load using ISAHS. The results obtained with proposed method are compared with the three existing methods. Convergence characteristics also show the efficiency of the proposed method.

Index Terms*: *Optimal Load Shedding, Improved adaptive Harmony Search Algorithm, Voltage collapse, Active and Reactive power.

I. INTRODUCTION

Power system security is one of the important factors to be maintained during the operation of a network. It is ability of the system to operate within the limits without actually reaching the state of emergency. However, in the actual scenario, it is not possible to operate within the limit always as there will be certain situations where there may be loss of generation, increase in load demand. In such a situation, the system constraints are violated, and the system goes out of the operational limits. During this disturbance to bring the system back into the stable state, there has to be the mechanism to adjust the factors driving the security of the network. Generally, the networks are equipped with the mechanism to deal with such contingency situations or disturbances to control the security and stability of the system. But it is not always possible to achieve this with the built-in mechanism and it may lead to cascaded tripping and the complete blackout in the system. In the view of avoiding complete black out , optimal load shedding is used as the last option and may be considered as the emergency option. Load shedding involves removal or reduction of certain amount of load from the connected load so that power system returns to the balanced stable state. The key aim of optimal load shedding is to curtail or reduction of the load in such a way that difference between the supplied active(real) and reactive power and connected active(real) and reactive power is reduced.When formulating the network behaviour with a mathematical model, the active and reactive powers are modelled as the dependent variables. These dependent variables are expressed as a function of the bus voltage. Basically, the load shedding scheme is categorized into Under frequency Load shedding (UFLS) and Under voltage load shedding (UVLS). When the power system experiences the generator loss or contingency issues, the voltages and frequencies in the busses drop. The new loads that are required to be adjusted to bring the power system back into the balanced state can be designed by measuring the voltage drop or frequency drop. The load shedding mechanism is triggered in a power system when the bus voltages or the frequencies fall below certain threshold values.

Raghu (2017) in their work have conducted an exhaustive study on research towards methods adopted for load shedding in power system such as Genetic Algorithms (GA), Simulated Annealing (SA), Tabu Search (TA), Ant colony optimization (ACO), Artificial Neural, Practical Swarm optimization (PSO), Artificial Bee Colony (ABC) , Maximum Loading Point (MLP) , Backtracking search algorithm, fuzzy logic , Artificial Neural Network, Shuffled frog leaping algorithm (SFLA) and Harmony Search (HS), Empirical approach. In this paper, ISAHS is implemented in order to achieve the optimal load shedding.

In 2001 Geem first implemented Harmony Search algorithm [2]. HS is similar to the PSO in the sense that it also focuses on the music improvisation process. A musician generates a tone and if the tone generated is better than the previous one, then it is stored. During the Jazz improvisation in way the musician keeps on searching for the better state of harmony in finding the best musically pleasing harmony, which is considered as a perfect state. This is almost like to obtaining the global solution that satisfies the objective function. The artistic quality is determined by the pitch of every musical instrument similarly as like objective function is estimated by a set of design values of active and reactive load . Advantage of using HS over other heuristic algorithms is as follows [3].

Manuscript published on 30 June 2019.
***** Correspondence Author (s)
Raghu C N*, Electrical & Electronics Engineering, Research Scholar, JAIN University , Assistant Professor , REVA University, Bengaluru, Karnataka, INDIA.
A Manjunatha, Electrical & Electronics Engineering, Sri Krishna Institute of Technology, Visvesvaraya technological university, Belgaum, Karnataka, INDIA.
G Raghavendra, School of Electrical & Electronics Engineering, REVA University, Karnataka, INDIA.

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication (BEIESP)

There is no inevitability to initialize the values for the decision variables. The mathematical formulation is simple, and it uses stochastic searches. There are no computations of derivatives in the search algorithm. Compared to GA, which generates a new vector considering only two parent vectors, HS considers all the existing vectors. HS produces the solutions much faster than other heuristic algorithms as this is very key to prevent the back out. The remedial mechanism must be fast enough to respond to the perturbation to the power system so that the optimal load shedding is recommended as quickly as possible so that blackout can be avoided.

Mahdavi in 2007 proposed an Improved harmony search (IHS) algorithm [4]. The improvement was in the way the new vector was computed. The new vector computation was based on dynamic adjustment of Pitch adjustment rate. Omran. proposed a global best harmony search algorithm[5] based on the particle swarm optimization. In this method best harmony is achieved by modifying pitch adjustment rate.

Another improvement in the harmony search was proposed by Zou[6], namely, Novel Global Harmony Search (NGHS or GHS) in which the features of the harmony search, PSO and Gene Mutation are combined. Another HS algorithm that was based on the theories and application of chaos is proposed by Geem [7]. With this approach, authors proved that the global convergence rates were faster. Li_min has proposed an improved adaptive harmony search algorithm [8] and had proved that performance of ISAHS was better than the HS, IHS or GHS. The defects of HS like falling into local minima, low accuracy etc were removed in ISAHS.

The optimal load shedding was implemented with optimization of sum of squares of difference in load power and generated power [9, 10, 12, 13]. A second order gradient technique (SOGT) was introduced in [11] in order to optimize the objective function. A new sensitivity based approach was presented in [14] to minimize the loss of load. The loads to be dropped are prioritized with the help of weighted errors. The load shedding and the rescheduling of the generators were modelled as non-linear problem [15, 16] in which the problem was approximated with a sensitivity model. The non-linear nature of the model was addressed with linear programming. Other approaches in the rescheduling and optimal load shedding have been optimizing the function of change of line over load to bus power changes [17, 18]. The network load flow equations were analyzed using a mesh approach in [19] in which the features of the impedance matrix and nodal admittance matrix were combined to solve the network equations. A new power flow model was proposed to address the abnormal operating conditions in large power systems in [20]. In [21], authors proposed solutions in a mesh type distributed system considering the restore times and failure rates. PSO and SA were combined to give solution to the load shedding problem in [22]. Melodi et al. [23] has explained a model for cost and system unavailability by using the statistics of frequency distribution from Nigerian Township. The combined work of Symon and Ragland [24] expressed the particle swarm optimization (PSO) based demand management for distributive power system.

The voltage stability margin was added in to this model to increase the sensitivity.

A different model, a Newton-Raphson method and Kuhn-Tucker theorem is used for optimal load shedding in this method loads were assumed to be independent of the bus voltage [25]. Other load shedding schemes include voltage dependant model [26]. During the contingency, to achieve the optimal load shedding Improved Harmony search has been implemented. In this approach, the loads were assume be dependent on the bus voltage.

In this paper, a proposed adaptive harmony search method is proposed. In conventional HS algorithm, the value of PACR, BW and PAR are not dynamic intern these values are constant. Improvisation is proposed for the conventional method. The new solution vector generated is based on the dynamic adjustment of PAR and BW parameters doing this there is an improvement in accuracy and convergence rate. in his improvisation in order to ensure the diverse in solution , HMCR parameter in HS algorithm adopt the linear increasing strategy. In order to avoid optimization end at local optima adaptive or dynamic value of PAR is proposed. In the proposed algorithm using nonlinear regressive strategy the dynamic value of BW is formulated. Hence the proposed method is better than the convolution method. The obtained results are compared and validated with existing methods.
This paper is organized with the following contents. In Sec. 2, the mathematical formulation is laid out to solve the network power flow equations. Also the different constraints are defined. In Sec. 3, detail of basic harmony search algorithm is presented along with the new features from improved adaptive harmony search algorithm. In Sec. 4, simulation results are presented for 14-Bus systems. Finally conclusion is drawn in Sec 5.

II. MATHEMATICAL FORMULATION

There may be a loss of generation or contingency during the normal working of the power system leading to the perturbation in system and this may be considered as the emergency state of the system. Consequently, to avoid black out load shedding is activated. The objective function is to minimize the difference between the connected active and reactive load and supply active and reactive power. However this objective function is subject to equality and inequality constraints.

$$min\ F = \sum_{i=1}^{NB} \alpha_i |P_{di} - \overline{P_{di}}|^2 + \beta_i\, |Q_{di} - \overline{Q_{di}}|^2 \quad (1)$$

where

NB: Number of busses
Pdi: Active power before load shedding
Qdi : Reactive power before load shedding
$\overline{P_{di}}$: Active power after load shedding
Q_{di} : Reactive power after load shedding
αi,βi : Weighting factors. The values for these weights may be found in [27].
Equality constraints are:

$$P(V) = P_{Gi} - P_{di}(V) - V_i \sum_{i=1}^{NA} V_j Y_{ij} \cos(\delta_i - \delta_j - \theta_{ij}) = 0 \quad (2)$$

$$Q(V) = Q_{Gi} - Q_{di}(V) - V_i \sum_{i=1}^{NA} V_j Y_{ij} \sin(\delta_i - \delta_j - \theta_{ij}) = 0 \quad (3)$$

Inequality constraints are:
Generator active power output:

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication (BEIESP)

$$P_{Gi}^{min} \le P_{Gi} \le P_{Gi}^{max},\ i = 1,2,3, \dots \dots, \mathrm{NG} \quad (4)$$

Generator reactive power output:

$$Q_{Gi}^{min} \le Q_{Gi} \le Q_{Gi}^{max},\ i = 1,2,3, \dots \dots, NG \quad (5)$$

Generator bus voltages:

$$V_i^{min} \le V_i \le V_i^{max},\ i = 1,2,3, \dots \dots, \mathrm{NB} \quad (6)$$

Apparent power flow in transmission lines:

$$S_{Li} \le S_{Li}^{min},\ i = 1,2,3, \dots \dots, NTL \quad (7)$$

Where

P_{Gi}^{min}: Minimum real power generation
P_{Gi}^{max}: Maximum real power generation
Q_{Gi}^{min}: Minimum reactive power generation
Q_{Gi}^{max}: Maximum reactive power generation
V_i^{min} : Minimum limit of the bus voltage
V_i^{max} : Maximum limit of the bus voltage
S_{Li}^{min} : Minimum limit of the severity of the system loading

In this paper, load shedding scheme is implemented based on the priority in the bus system. Priority is derived based on the voltage drop in the bus. After, generation loss or contingency, the voltage drops are computed using the MATPOWER. The voltage drop for each of the bus is used to rank the bus system. Bus with largest drop is ranked as one is assigned with higher penalty and so on. When the load shedding is planned, the bus with higher penalty shed with maximum load shedding range and the bus with least penalty is load shed range is minimum. This is achieved by first calculating the excess power demand, which is the difference between the connected active and reactive load; and supply active and reactive power. The total load shed is proportional to the excess power demand and is distributed to all the buses based on the calculated penalty of the bus. The drop in the bus voltage may be considered as a measure of voltage stability.

III. HARMONY SEARCH ALGORITHM

In any harmony search algorithm, the objective is to minimize the aesthetic standard or objective function. That is

$$\min f(x) \text{ such that } x_i \in X_i,\ i=1,2,3,\dots\dots,N \quad (8)$$

where N is the number of decision variables. Each decision variable have range starting from xiL to xiU.
xiL is the lower limit for the decision variable xi and xiU is the upper limit. Xi is the range of values that xi can take. Xi has the values between xiL and xiU. The following parameters and definitions are important to understand the harmony search algorithm.
The vector xi is called as Harmony and set of xi is known as Harmony memory. The Harmony memory or HM is the matrix that holds the set of xi. The size of HM is Harmony memory size M. The size of HM matrix is then M x N. Therefore HM may be written as

$$HM = \begin{bmatrix} x_1^1 & x_2^1 & \cdots & x_N^1 \\ x_1^1 & x_2^2 & \cdots & x_N^2 \\ \vdots & \vdots & \vdots & \vdots \\ x_1^M & x_1^M & \cdots & x_N^M \end{bmatrix} \quad (9)$$

The HM matrix is initialized with random values with

$$x_i = x_i^L + \mathrm{RAND1}[0,1](x_i^U - x_i^L) \quad (10)$$

The RAND1[0, 1] is the random number generator, usually uniform distribution random generator is used. The value of f(xi) is used for each of the vector in the HM. A new harmony xiNew is generated and the objective function value of this new harmony is evaluated. If the estimated objective function value is better than the worst harmony in terms of objective function value, in HM, at that point the worst harmony in HM is replaced with the new harmony. This process is repeated for certain number of cycles or iterations. The number of iterations can also be considered as one of the parameters of the HS algorithm. Now the challenge is to generate the new harmony xiNew. The following steps are followed to generate the new harmony xiNew.There are two ways that can be generated. The first one is to select the xiNew from HM and then mutate it. The second method is to randomly select it from the generic set . The harmony considerate rate [HMCR] is the probability that is selected from HM and [1-HMCR] is the probability that it is selected from the generic set Xi. When the xiNew is selected with a probability of HMCR, it is mutated as below when Xi is continuous.

$$x_i^{New} = \begin{Bmatrix} x_i^{New} \pm RAND2[0,1]BW, RAND2[0,1] < PAR \\ x_i^{New} \ \ otherwise \end{Bmatrix} \quad (11)$$

where the BW is arbitrary chosen separately for each of the decision variables.
When Xi is discrete,

$$x_i^{New} = \begin{Bmatrix} x_i^{(k+m)} \pm m \in [1,-1], , RAND2[0,1] < PAR \\ x_i^{New} \quad Otherwise \end{Bmatrix} \quad (12)$$

Based on HMCR, the decision about xiNew is to be generated form HM or Xi is taken and, if it is chosen from HM, the PAR is used to decide if xiNew it to be mutated or not. Hence HMCR, PAR and BW play an significant part in deciding the convergence rate of the solution. The improved self adaptive harmony search algorithm (ISAHS) [17], in which the HMCR, PAR and BW is calculated as

$$\mathrm{HMCR}(t) = \mathrm{HMCR_{max}} - \frac{(\mathrm{HMCR_{max}} - \mathrm{HMCR_{min}})(t)}{\mathrm{N_{iter}}} \quad (13)$$

$$PAR(t) = PAR_{min} + \frac{(PAR_{max} - PAR_{min})\mathrm{ARCTAN}\,(t)}{\left(\frac{\pi}{2}\right)} \quad (14)$$

$$BW(t) = BW_{min} + (BW_{max} - BW_{min})\mathrm{EXP}\,(-t) \quad (15)$$

Where
HMCRmax=Maximum harmony memory considerate rate
HMCRmin=Minimum harmony memory considerate rate
PARmax =Maximum pitch adjustment rate
PARmin = Minimum pitch adjustment rate
BWmax =Maximum bandwidth
BWmin = Minimum bandwidth
Niter = Number of iterations
The ISAHS algorithm can be summarized as

1. Initialize the parameter of ISAHS algorithm
2. Populate the HM with the random vectors
3. Determine the HMCR, PAR and BW based on the parameters and the iteration count using equations 13, 14 and 15.
4. Generate new solutions using equations 10, 11 and 12.
5. Determine the objective function value as per the equation 9. If the objective function value is better than the worst vector present in HM, then replace the worst vector with new vector. Else repeat step 4.
6. Verify if the termination condition of maximum number of iterations are met and terminate the algorithm. Else, repeat steps 4 and 5.

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication (BEIESP)

In this research work, the network power flow equations are solved using MATPOWER and the load shedding is performed using the ISAHS.

IV. SIMULATION RESULTS

In this section, simulation results are presented for the system IEEE-14 Bus. The simulations are performed on the MATLAB with MATPOWER toolbox and the ISAHS algorithm for load shedding. The parameters used in the IHAS are:

HMS or M =100, HMCRmax=0.9, HMCRmin=0.2, PARmin=0.4, PARmax= 0.9, BWmin = 0.0001, BWmax =1.0, Niter = 5000

The load shedding results are compared with three methods, namely, PALM , GSO and IHS. The simulations are run on an Intel i5 processor with 4GB RAM.

A. Simulations Results for IEEE-14 Bus

The 14-Bus system has 2 Generators, 3 Transformers, 3 Synchronous Condensers 20 Lines and 1 Static Capacitor. Inequality constraints are:

$$0 \le P_{G1} \le 200, -150 \le Q_{G1} \le 150, 0 \le Q_{Gi} \le 140, i = 2,3,6,8$$

Table 1 shows the active and reactive supplied under the normal operating conditions for the IEEE-14 Bus. The supplied powers are compared with the three methods such as projected augmented Lagrangian method(PALM) [20] using MINOS optimization package and NR-VDLM [21,33] implemented using nature inspired optimization algorithm known as GSO algorithm and HIS algorithm respectively. The total active power supplied with the proposed method is 259MW which is comparable with the other three methods. The supplied active powers with PALM and NR-VDLM are 258.59 MW and 258.8 MW respectively. Similarly the reactive power is 73.5MVAR and is again very close to the supply estimated by the other three methods. The supplied reactive powers with PALM and NR-VDLM (GSO, IHS) are 73.51 MVAR and 72.92 MVAR respectively.

Table 1: Total Active and Reactive Supply for IEEE 14-Bus in Various Load Shedding Scheme under Normal Operating Condition

	PALM		NR-VDLM(GSO)		NR-VDLM(IHS)		ISAHS	
	MW	MVAR	MW	MVAR	MW	MVAR	MW	MVAR
Total Load	258.59	73.51	258.801	72.920	258.801	72.92	259	73.5

The range of bus voltage swing in PALM and NR-VDLM(GSO, HIS) are 0.98 pu to 1.07 pu and 1.01 pu to 1.08 pu respectively, where as the voltages are 1.01pu to 1.062pu in ISAHS method. Table 2 shows the generated active and reactive powers of the four methods. Again, active and reactive powers generated using proposed method is very close to that of the other three methods.

Table 2: Active and Reactive Generation for IEEE 14-Bus in Various Load Shedding Scheme under Normal Operating Condition

BUS	PALM		NR-VDLM(GSO)		NR-VDLM(IHS)		Proposed Method	
	MW	MVAR	MW	MVAR	MW	MVAR	MW	MVAR
1	69.25	-64.43	200	-16.5	200	-16.5	198.8	-9.29
2	200	0	72	43.6	72	43.6	72	31.2
3	0	47.5	0	25.1	0	25.1	0	25.02
6	0	61.26	0	12.7	0	12.7	0	12.71
8	0	34.84	0	17.6	0	17.6	0	17.6
Total	269.25	79.17	272	82.5	272	82.5	270.8	77.24

Table 3 shows the powers supplied when the second generator is off. The loss of generation is 72MW and it is close to 26% of the total power generated. When the 72MW of power was lost the connected load to the bus system was at 259 MW. The loads were shed using the ISAHS based methods that used the ISAHS algorithm for load shedding. Table 3 shows the active power supplied to the loads. A total of 193.47MW was supplied to the bus system using proposed scheme. The amount of real load shed is 65.53MW, which is 25.3% where as it was 66.875MW, which is 25.84% using NR-VDLM(IHS) method. And in it was 66.5MW, which is 25.67% using NR-VDLM(IHS) method. The load shed using PALM methods are 71.11MW [21]. It is very clearly understandable from the results presented in Table 3 that, compared to all other method the load shed using proposed method is least . Table 4 shows the generated powers by all the four methods after the load shed.

Table3: Active and Reactive Supply for IEEE 14-Bus under Abnormal Operating Condition

BUS	PALM		NR-VDLM(GSO)		NR-VDLM(IHS)		Proposed Method	
	MW	MVAR	MW	MVAR	MW	MVAR	MW	MVAR
1	0	0	0.0	0	0	0	0	0
2	16.55	9.69	16.179	10.562	17.51	10.562	19.52	11.03
3	75.24	15.18	75.268	15.672	72.298	15.672	66.17	10.45
4	35.21	-2.87	35.988	-2.603	32.25	-2.603	34.95	-3.33

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication (BEIESP)

5	5.64	1.19	4.483	1.232	5.63	1.232	5.59	1.48
6	7.03	4.71	6.831	5.994	7.462	5.994	9.4	6.05
7	0	0	0	0	0	0	0	0
8	0	0	0	0.683	0	0.683	0	0
9	19.28	10.85	21.719	11.930	20.276	11.93	21.39	15.13
10	5.75	3.71	6.273	4.217	7.543	4.217	7.3	2.13
11	2.2	1.13	2.277	1.842	2.682	1.842	2.72	1.04
12	3.73	0.98	3.996	1.138	4.576	1.138	4.55	1.04
13	8.22	3.53	9.241	4.724	12.041	4.874	9.76	3.66
14	9.04	3.03	9.880	3.914	11.081	3.914	12.12	3.21
Total	187.89	51.13	192.135	59.3050	192.51	59.41	193.47	51.89

Table 4: Active and Reactive Generation for IEEE 14-Bus under Abnormal Operating Condition

BUS	PALM		NR-VDLM(GSO)		NR-VDLM(IHS)		Proposed Method	
	MW	MVAR	MW	MVAR	MW	MVAR	MW	MVAR
1	200	-6.65	200	-16.5	200	-16.5	200	-14.16
2	0	0	0	43.6	0	43.6	0	38.45
3	0	63.34	0	25.1	0	25.1	0	1.86
6	0	5.59	0	12.7	0	12.7	0	0.22
8	0	0	0	17.6	0	17.6	0	13.33
Total	200	62.28	200	82.50	200	82.5	200	39.7

It is obseved form Table 5, the power losses with the proposed method is 11.8MW and 6.53MW during normal and abnormal operating conditions. This is also less compared to the other methods.

Table 5:Active Power Loss for IEEE 14-Bus under Normal and Abnormal Operating Condition

Condition	PALM	GSO	IHS	Proposed Method
	MW	MVAR	MW	MVAR
Normal	10.6685	13.2	13.2	11.8
Abnormal	12.1111	7.865	7.49	6.53

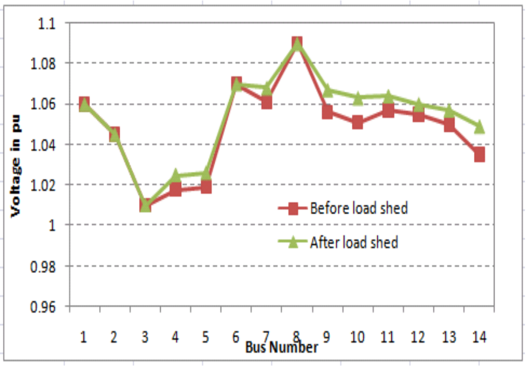

Figure 1: Voltage magnitude in pu before the load shed (after generation loss) and after the load shed

Figure 1 shows the voltage magnitudes in pu before the load shed and after the load shed. The voltage magnitudes before the load shed are estimated after considering the loss of generation. It is observed that there is considerable enhancement in the voltage magnitudes after the load shed with the proposed method

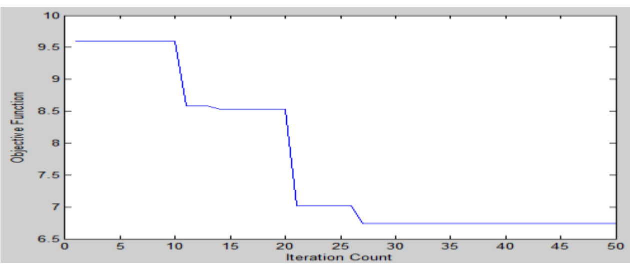

Figure 2: Convergence characteristics for IEEE-14 Bus with ISAHS

Figure 2 shows the convergence characteristics with ISAHS. It is observed that objective function has converged very fast with less iteration, where as in NR-VLDM with GSO and IHS scheme, the objective function convergence is slow [33]. Hence the ISAHS converged faster than the IHS algorithm for the load shedding in IEEE-14 bus.

V. CONCLUSION

In this work, an optimal load shedding algorithm is designed to determine the optimal amount of load curtailment. To avoid the voltage collapse using an improved adaptive harmony search algorithm and the MATPOWER power flow solver an novel load shedding algorithm is proposed. The test results on IEEE-14 an IEEE-30 bus system shows the slight improvement the active, reactive powers supplied, power loss in the system .The proposed method is tested for generation loss contingency. For a 14-Bus system a loss of 72 MW and for 30-Bus system, a loss of 70 MW was assumed. For a 14-Bus system, the amount of load shed using proposed method is 65.53MW, which is 25.3% where as it was 66.5MW, which is 25.67%, using NR-VDLM(IHS) method. For a 30-Bus system the amount of load shed with proposed method is 38.06 MW, which is 13.43% where as it was 38.467MW, which is 13.55%, using NR-VDLM(IHS) method. Hence the proposed ISAHS method yielded better performance than any other methods referred in safeguarding system against voltage collapse. This innovative technique shown that the convergence rates using ISAHS is much faster than that of the other method. The proposed method was found to be effective for small and medium bus system. In future work the proposed method requires testing of performance for large system like IEEE-116 bus system. And also, it can be tested for (N-1) contingency condition. To improve the steady state of power system in terms of both frequency and voltage in future the frequency component need to be considered in every stage of load shedding.

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication (BEIESP)

ACKNOWLEDGMENT

It is optional. The preferred spelling of the word "acknowledgment" in American English is without an "e" after the "g." Use the singular heading even if you have many acknowledgments. Avoid expressions such as "One of us (S.B.A.) would like to thank ... ." Instead, write "F. A. Author thanks " *Sponsor and financial support acknowledgments are placed in the unnumbered footnote on the first page*.

REFERENCES

1. Raghu C N, A Manjunatha, "Assessing Effectiveness of Research for Load Shedding in Power System" *International Journal of Electrical and Computer Engineering (IJECE)*, ,Vol. 7, No. 6, pp. 3235-3245, *2017..*
2. Lee K.S, Geem Z.W, Lee S.H and Bae K.-W, "The harmony search heuristic algorithm for discrete structural optimization", *Engineering Optimization*, 2005, 37(7): 663- 684, 2005.
3. Geem Z.W, "Harmony search algorithm for solving Sudoku", In: *Proc. of the 11th international conference, KES 2007 and XVII Italian workshop on neural networks conference on Knowledge-based intelligent information and engineering systems*: Part I., *Springer-Verlag: Vietri sul Mare*, Italy, 2007
4. Mahdavi M, M. Fesanghary, and E. Damangir, "An improved harmony search algorithm for solving optimization problems", *Applied Mathematics and Computation*,. 188(2): pp. 1567-1579, 2007
5. Omran M.G.H and M. Mahdavi, "Global-best harmony search", *Applied Mathematics and Computation*,. 198(2): p. 643-656, 2008.
6. Zou D, "A novel global harmony search algorithm for reliability problems", *Computers & Industrial Engineering*,. 58(2): p. 307-316, 2010.
7. Geem Z.W, Choi J.Y, "Music composition using harmony search algorithm", In: *proc. of Giacobini. M (ed.) Evo Workshops. LNCS*, vol. 4448, pp. 593–600, *2007*.
8. Li-min Zhang, "An Improved Adaptive Harmony Search Algorithm", In: *proc. of International Conference on Computational Science and Engineering* (ICCSE 2015), 2015
9. Mostafa MA, El-Harwary ME, Mbamalu GAN, Mansour MM, El-Nagar KM, El-Arabaty AM, "A computational comparison of steady state load shedding approaches in electric power systems", *IEEE Transaction on Power System*;12(1), 1997
10. Hajdu LP, Peschon J, Tinney WF, Piercy DS, "Optimal loadshedding policy for power systems", *IEEE Transaction*;PAS-87(3):784–95, *1968*
11. Palaniswamy KA, Sharma Misra KB, "Optimum load shedding taking into account voltage and frequency characteristics of loads", *IEEE Transaction*; PAS-104(6):1342–8, *1985*
12. Mostafa MA, El-Harwary ME, Mbamalu GAN, Mansour MM, El-Nagar KM, El-Arabaty AM, "Steady-state load shedding schemes: a performance comparison", *Electrical Power System Research*;38:105–12, *1996*.
13. Mostafa MA, El-Harwary ME, Mbamalu GAN, Mansour MM, El-Nagar KM, El-Arabaty AM, "Optimal dynamic load shedding using a Newton based dynamic algorithm*", Electrical Power System Research*;34:157–63, *1995*.
14. Subramanian DK, "Optimum load shedding through programming techniques", *IEEE Transaction*;PAS-90(1):89–95, *1971*.
15. Chan SM, Schweppe FC, "A generation reallocation and load shedding algorithm", *IEEE Transaction*;PAS-98(1):26–34, *1979*
16. Chan SM, Yip E, "A solution of the transmission limited dispatch problem by sparse linear programming", *IEEE Transaction*; PAS-98(3):1044–53, *1979*.
17. Medicherla TKP, Billinton R, Sachdev MS, "Generation rescheduling and load shedding to alleviate line overloads analysis", *IEEE Transaction*;PAS-98:1876–84, *1979*
18. Medicherla TKP, Billinton R, Sachdev MS, "Generation rescheduling and load shedding to alleviate line overloads-system studies", *IEEE Transaction*;PAS-100(1):36–41, *1981*.
19. Freris LL, Sasson AM, "Investigation of load flow problem", *In: Proc. of IEEE*; 115:1459–70, *1968*.
20. Okamum M, O-ura Y, Hayashi S, Uemura K, Ishiguro F, "A new power flow model and solution method including load and generator characteristics and effects of system control devices", *IEEE Transaction*;94:1042–50, *1975*.
21. Arya LD, Singh Pushpendra, Titare LS, "Differential evolution applied for anticipatory load shedding with voltage stability considerations", *Electrical Power Energy System*; 42:644–52, *2012*.
22. Sadati N, Amraee T, Ranjbar AM, "A global particle swarmbased-simulated annealing optimization technique for undervoltage load shedding problem", *Applied Soft Computing*;9:652–7, *2009*.
23. Oladipo, Melodi Adegoke, and Temikotan Kehinde Olusesan. "A Model Unavailability Perspective of Existing Nigerian Township Electricity Distribution." International Journal of Electrical and Computer Engineering (IJECE) 7, no. 1 (2017): 77-85.
24. Tibbie Pon Symon V.A., I. Jacob Ragland, "Improving Efficiency of Power Systems by Demand Side Management Method", International Journal of Electrical and Computer Engineering (IJECE), 7, no. 1, 2016.
25. L. P. Hajdu, J. Peschon, W. F. Tinney, and D. Piercy, "Optimum loadshedding policy for power systems," *IEEE Transactions on Power Apparatus and Systems*, pp. 784-795, 1968.
26. R. Mageshvaran and T. Jayabarathi, "Steady state load shedding to mitigate blackout in power systems using an improved harmony search algorithm," *ASEJ Ain Shams Engineering Journal*, vol. 6, pp. 819-834, 2015.
27. Mageshvaran R, Jayabarathi T, "GSO based optimization of steady state load shedding in power systems to mitigate blac,kout during generation contingencies", *Ain Shams Engineering Journal* (2014), http://dx.doi.org/10.1016/j.asej.2014.09.010, 2014

AUTHORS PROFILE

Raghu C N did his BE from Adhichunchanagiri Institute of Technology in 2006 and MTech degree in Digital Electronics form Sri Siddhartha Institute of Technology Tumkur in 2011. He is currently an As Assistant Professor in School of Electrical & Electronics Engineering department in REVA University Bangalore. And pursuing his PhD in Jain University. His research interests are Power systems security, Power system stability, Power quality etc. Email: raghuresearch13@gmail.com, Mob: 9844628735

A Manjunatha did his BE from Mysore University, ME in Power Systems from Bangalore University, andPhD from Dr.M.G.R University Chennai. He is currently working as principal at Sri Krishna institute of technology, Bangalore; Karnataka.He is currently guiding PhD and MSc engineering students in the area of power system operation and control, power system reliability evolution, power system deregulation and power quality. He is the life member of Indian Society for Technical Education also member of Institute of Engineers (India).

Prof. G. Raghavendra, Assistant Professor in the school of Electrical and Electronics Engineering in REVA University holds B.E in Electrical and Electronics Engineering from Dr. TTIT, K.G.F and M.Tech. in Digital Electronics from SSIT, Tumkur and andPhD from JAIN University. He has 16 years of teaching experience, teaching various subjects like Network Analysis, Control systems, Modern control Theory, Electrical Drawing and Basic Electrical Engineering. His area of interest is in power systems, distribution generation, optimization.