ISSN 2277 – 8322

Reduction of Distribution Losses by combined effect of Feeder Reconfiguration and Optimal Capacitor Placement

Sarfaraz Nawaz[1], Nikita Jhajharia[2], Tanuj Manglani[3]

[1]*Associate Professor, Department of Electrical Engg. , SKIT, Jaipur, India*

[2]*Associate Professor, Department of Electrical Engg. , MNIT, Jaipur, India*

[3]*Associate Professor, Department of Electrical Engg. , YIT, Jaipur, India*

Email: eesarfaraz1983@rediffmail.com, idtanuj@gmail.com

Abstract - The electric power distribution system usually operates in a radial configuration, with tie switches between circuits to provide alternate feeds. The losses would be minimized if all switches were closed, but this is not done because it complicates the system's protection against over currents. Whenever a component fails, some of the switches must be operated to restore power to as many customers as possible. As loads vary with time, switch operations may reduce losses in the system. Both of these are applications for reconfiguration. To get the distribution network to operate at its optimum performance in an automated distribution system reconfiguration was been proposed and researched.

After feeder reconfiguration the losses of the radial system is found to be minimum but the buses has under voltage. To overcome this problem a optimal capacitor placement method is implemented. This will calculate the exact and optimal number of capacitor bank. This will help in reduction of losses and improvement of bus voltages.

Keywords – Capacitor Placement, Distribution System, ETAB, Feeder configuration, Losses , Voltage, Capacitor Cost

I. INTRODUCTION

The distribution system is the most visible part of the supply chain, and as such most exposed to the critical observation of its users. It is, in many cases, the largest investment, maintenance and operation expense, and the object of interest to government, financial agencies, and associations of concerned citizens. About 30 to 40 % of total investments in the electrical sector go to distribution systems, but nevertheless, they have not received the technological impact in the same manner as the generation and transmission systems. Many of the distribution networks work with minimum monitoring systems, mainly with local and manual control of capacitors, sectionalizing switches and voltage regulators; and without adequate computation support for the system's operators.

In order to increase the efficiency of the distribution electrical networks, a reconfiguration process was applied to improve the reliability indices. Considering Feeder reconfiguration for loss minimization was first proposed by Merlin *et al*. [1] using a discrete branch and bound technique.

In this method all the network switches are closed to form a meshed system, and then the switches are opened successively to restore to the radial configuration. However, this method involves approximations. Shirmohammadi *et al*. [2] proposed an algorithm to overcome these approximations. In this method, the switches are opened one by one, based on an optimal flow pattern. Peponis *et al.* [3] have developed a methodology for the optimal operation of distribution network. In this method loss minimization is obtained by installation of shunt capacitors and reconfiguration of the network. Schmidt *et al.* [4] have formulated the problem as a mixed integer nonlinear optimization problem. The integer variables represent the status of the switches, and continuous variables represent the current flowing through the branches. Broadwater *et al.*

[5] have considered the time varying load demand, obtained through load estimation, to reduce the loss. Morton *et al.* [6] have proposed a method based on an exhaustive search algorithm for obtaining a minimum loss radial configuration of a distribution system. The algorithm uses the graph-theoretic techniques involving semi-sparse transformations of a current sensitivity matrix. M.W. Siti *et al.* [7] contribute such a technique at the low-voltage and medium-voltage levels of a distribution network simultaneously with reconfiguration at both levels. While the neural network is adopted for the network reconfiguration problem, this paper introduces a heuristic method for the phase balancing/loss minimization problem. A comparison of the heuristic algorithm with that of the neural network shows the former to be more robust. K. Viswanadha Raju *et al.* [8] describes a new, two stages, and heuristic method, for determining a minimum loss configuration of a distribution network, based on real power loss sensitivities with respect to the impedances of the candidate branches. S.K.Salam *et al.* discussed [9], the effects of distributed generation on voltage regulation and power losses in distribution systems C.L.T. Borges *et al.* [10] have presented a technique to evaluate the impact of DG size and placement on losses, reliability and voltage profile of distribution networks. Davidson *et al.* [11] have presented an optimization model for loss minimization in a distribution network with DG. An algorithm has been proposed by T.Griffin *et al.* [12] to determine the near optimal placement of distributed generation with respect to system losses. Mutale *et al.* [13] have presented a methodology to evaluate the impact of DG on power loss minimization by examining loss allocation coefficients. M. A. Kashem *et al.* [14] represent techniques to minimize power losses in a distribution feeder by optimizing DG model in terms of size, location and operating point of DG. Sensitivity analysis for power losses in terms of DG size and DG operating point has been performed. X. P. Zhang *et al.* [15] paper discusses the issue of energy loss minimization of electricity networks with large renewable wind generation. The impact of the special operating arrangements of large wind generation on energy loss of electricity networks is investigated. An optimal power flow (OPF) approach is proposed to minimize the energy loss of electricity network with reactive power and FACTS control, while satisfying the network operating voltage and thermal limits. W.M.Lin *et al*. [16] propose to reduce power loss by means of load reconnection of the prime phase sequence of the open wye - open delta transformers. The Genetic Algorithms (GAs) has been implemented for solving the optimal problem. Practical examples of Taiwan Power Company demonstrate that the proposed method is effective and available. M.S.Tsai *et al.* [17] compares several Genetic Algorithm reproduction methods for distribution system loss reduction and load balancing problems. Asexual reproduction method is proposed in this paper, which requires less generation to reach the optimal solution than gamogenesis. A.Augugliaro *et al.* [18] discussed the problem of voltage regulation and power losses minimization for automated distribution systems. The classical formulation of the problem of optimal control of shunt capacitor banks and Under Load Tap Changers located at HV/MV substations has been coupled with the optimal control of tie-switches and capacitor banks on the feeders of a large radially operated meshed distribution system with the aim of attaining minimum power losses and the flattening of the voltage profile. The considered formulation requires the optimization of two different objectives; therefore the use of adequate multi objective heuristic optimization methods is needed. The heuristic strategy used for the optimization is based on fuzzy sets theory. K.Amaresh *et al.* [19] introduced HVDS with small capacity distribution transformers. A simple load flow technique has been used for solving radial distribution networks before and after implementation of HVDS. An advantage of implementing HVDS over LVDS system for loss minimization is discussed .T.M.Khalil *et al.* [20] presented a solution by using series capacitors connected to the nodes of distribution feeders. A proposed technique is introduced to calculate the desired size of series capacitors keeping the voltage at

proper nominal operating limits and reducing the power losses. This technique is the Particle Swarm Optimization (PSO). A real case study is presented as an illustrative example showing the advantages of the proposed technique over other methods.

This paper proposes a loss minimization for power distribution system. Two methods of loss reduction (Feeder Reconfiguration, Optimal Capacitor Placement) are implemented on IEEE – 70 Bus systems.

II. FEEDER RECONFIGURATION (FR)

Distribution networks are configured radially. Their configurations may be varied with manual or automatic switching operations so that all of the loads are supplied and reduce power loss, increase system security, and enhance power quality. Reconfiguration also relieves the overloading of the network components. The change in network configuration is performed by opening sectionalizing (normally closed) and closing tie (normally open) switches of the network. These switching's performed in such a way that the radiality of the network is maintained and all of the loads are energized.

"Feeder reconfigurations are defined as altering the topological structures of distribution feeders by changing the open/closed states of the sectionalizing and tie switches" [21].

III. PROPOSED FR METHOD

To obtain minimum loss radial configuration the sectionalizing switch out of the sectionalizing switches on either side of the hypothetical switch carries more complex power should be kept closed and the other is opened.

The algorithm of the proposed method is as follows:

(i) Read the data and switch data

(ii) Close all normally open switch to form an interconnected network

(iii) Perform load flow study and obtain results.

(iv) Identify the nodes which are receiving power from more than one source.

(v) Compare the complex power flows toward the each individual identified node. Open the line section(s) feeding less complex power to individual identified node.

(vi) Print the resulting minimum complex power loss radial configuration.

For experimental study of above method, 11 KV 70 bus, feeder system of Debapriya Das [21] is taken. The Line and Load details are given in Table VI. The proposed method of feeder reconfiguration is applied to the 70 bus system. ETAP 5.0 software is used for simulation.

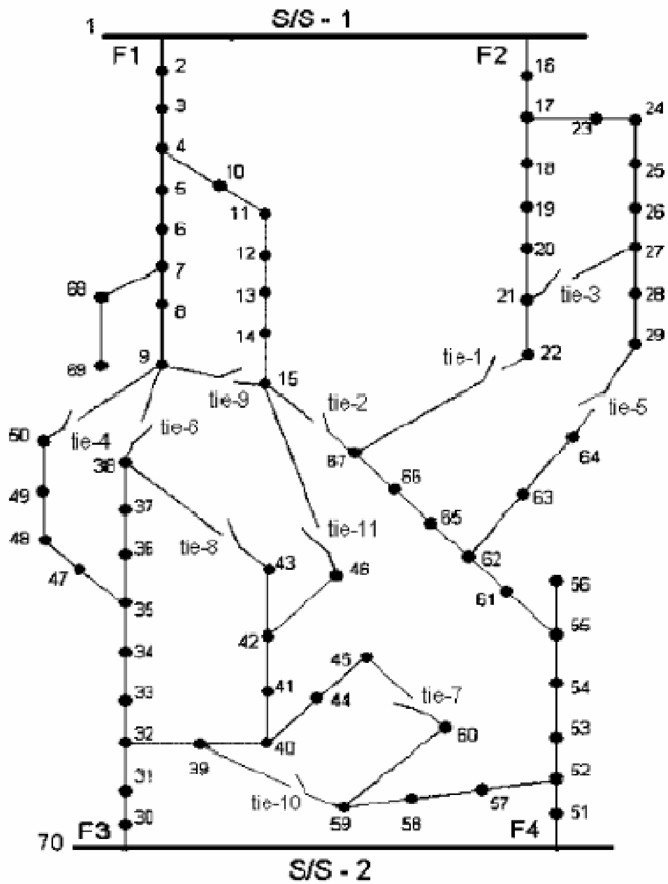

Fig. 1 IEEE 70 bus system

Now, following buses are receiving complex power from two or more than two buses.

TABLE I
Details of Complex power received by bus

S.No.	To Bus	From Bus	Complex power
1	9	8 38	72+j67 66+j55
2	15	9 14 46	2+j41 43+j3 59+j40
3	27	21 26	191+j66 117+j119
4	38	37 43	27+j51 66+j26
5	39	32 59	511+j310 55+j31
6	40	39 44	427+j249 16+j14
7.	64	29 63	19+j12 8+j12
8	65	66 62	67+j53 48+j53
9	67	22 15	154+j126 69+j56
10	50	49 9	3+j9 122+j71
11	46	42 15	113+j76 95+j63

According to the method, open the line section which is feeding less complex power to individual identified node. Hence, following line section is opened.

TABLE II
Details of Tie Switch by Proposed Method

S.No.	Line Section (Tie Switch)	S.No.	Line Section (Tie Switch)
1	9 - 38	**6**	40 - 44
2	9 - 15	**7**	63 - 64
3	21 - 27	**8**	62 - 65
4	37 - 38	**9**	15 - 67
5	39 - 59	**10**	49-50
		11	15-46

Now, after performing the load flow analysis in ETAP software, total losses become 179 KW & 161.8 KVAR.

TABLE III
Voltages of 70 Buses after Feeder Reconfiguration Method

Bus No.	Voltage (pu)	Bus No.	Voltage (pu)	Bus No.	Voltage (pu)
1	1	**25**	0.940	**49**	0.9625
2	0.9854	**26**	0.938	**50**	0.940
3	0.968	**27**	0.936	**51**	0.9928
4	0.96	**28**	0.933	**52**	0.9653
5	0.959	**29**	0.9314	**53**	0.958
6	0.95	**30**	0.9967	**54**	0.9542
7	0.9455	**31**	0.991	**55**	0.950
8	0.944	**32**	0.958	**56**	0.949
9	0.943	**33**	0.9803	**57**	0.962
10	0.957	**34**	0.975	**58**	0.959
11	0.953	**35**	0.967	**59**	0.952
12	0.949	**36**	0.966	**60**	0.950
13	0.9467	**37**	0.9655	**61**	0.947
14	0.9461	**38**	0.9648	**62**	0.944
15	0.9452	**39**	0.9495	**63**	0.9437
16	0.982	**40**	0.947	**64**	0.9319
17	0.976	**41**	0.944	**65**	0.9399
18	0.966	**42**	0.940	**66**	0.9408
19	0.960	**43**	0.940	**67**	0.9446
20	0.955	**44**	0.9498	**68**	0.9438
21	0.948	**45**	0.9499	**69**	0.943
22	0.9456	**46**	0.939	**70**	1.0
23	0.9588	**47**	0.966		
24	0.947	**48**	0.963		

After this, it is seen that the minimum voltage at bus 29 is 0.93pu. Hence to improve this voltage another method, optimal capacitor placement, is applied to the system.

IV. OPTIMAL CAPACITOR PLACEMENT

Most utilities try to apply capacitors “optimally”. Years ago, when voltage levels were low and wire sizes were smaller, an “optimal placement study” might mean placement of the capacitor banks to obtain a reasonable voltage profile. Today, optimum placement normally means place to minimize losses at the lowest cost.

Placement Studies are normally performed in one of two ways:

(i) Place capacitors until optimum power factor is reached (point where the cost of adding bank exceeds value of losses reduction and equipment utilization benefits)

(ii) Place capacitors until a predetermined power factor is met. This number is Sometimes quite arbitrary.

Optimal placement would be easy if the load didn’t change. The problem with placement studies is that loads change during the day, week, month and most schemes have to deal with all these changes as best they can. The VAR needs change dramatically over a fairly brief period of time. The challenge to the distribution engineer is to pick the correct size of the banks to be used**,** the placement of these banks and minimize the cost.

V. PROPOSED OPTIMAL CAPACITOR PLACEMENT METHOD

After feeder reconfiguration methods, the total system losses are 179 KW & the minimum bus voltage is 0.933 (Bus no. 28). Here, the system voltage is under critical limits. Hence, to improve system voltage & also system losses it is desired to connect capacitor bank on the appropriate buses.

Algorithm of proposed OCP method:

1. Find the number of buses, which are opened after feeder reconfiguration method.
2. The system is radial. So, this will be the end buses of the particular feeder.
3. Calculate the total reactive power flow in the corresponding feeder.
4. Connect the capacitor banks of total VARS that is flowing in each radial feeder

Table IV
Location & Size of Capacitor Bank by Proposed Method

S.No.	**Location of capacitor bank Bus No.**	**Rating of Capacitor bank (KVAR / Phase)**
1	50	80
2	15	60
3	49	60
4	38	30
5	43	100
6	44	31
7	63	50
8	64	140
9	65	120

Now the system losses are: 136.6 KW & 122.4 KVAR
Total Rating of Capacitor Bank is 1.983 MVAR or 2 MVAR (approx.) .
Here it is seen that after applying Optimal capacitor placement method to the given system, the losses are reduced to 136 KW i.e. reduction of 43 KW.

TABLE V
Voltages of Buses after Optimal Capacitor Placement

Bus No.	**Voltage (pu)**	**Inc./ Dec.**	**Bus No.**	**Voltage (pu)**	**Inc./Dec.**
1	1	Swing	**36**	0.976	--
2	0.9878	Inc.	**37**	0.976	-
3	0.9739	Inc.	**38**	0.9764	Inc
4	1.05	Inc.	**39**	0.9853	Inc
5	0.99	Inc	**40**	0.9840	Inc
6	0.994	Inc	**41**	0.9821	Inc

7	0.9914	Inc	**42**	0.9815	Inc
8	0.9912	Inc	**43**	0.9834	Inc
9	0.991	Inc	**44**	0.9858	Inc
10	0.998	Inc	**45**	0.9856	Inc
11	0.995	Inc	**46**	0.9808	Inc
12	0.993	Inc	**47**	0.9759	-
13	0.991	Inc	**48**	0.97463	-
14	0.991	Inc	**49**	0.97441	-
15	0.992	Inc	**50**	0.9909	Inc
16	0.987	Inc	**51**	0.9938	Inc
17	1.01	Inc	**52**	0.9980	Inc
18	0.995	Inc	**53**	0.9923	Inc
19	0.9916	Inc	**54**	0.9893	Inc
20	0.9885	Inc	**55**	0.98626	Inc
21	0.9845	Inc	**56**	0.9856	Inc
22	0.9834	Inc	**57**	0.9952	Inc
23	0.9886	Inc	**58**	0.9927	Inc
24	0.98025	Inc	**59**	0.9872	Inc
25	0.9760	Inc	**60**	0.98586	Inc
26	0.9744	Inc	**61**	0.98413	Inc
27	0.9735	Inc	**62**	0.98214	Inc
28	0.9728	Inc	**63**	0.98235	Inc
29	0.9735	Inc	**64**	0.97416	Inc
30	0.9974	-	**65**	0.98127	Inc
31	0.9932	-	**66**	0.98113	Inc
32	0.9895	-	**67**	0.9829	Inc
33	0.9856	-	**68**	0.98971	Inc
34	0.9802	-	**69**	0.988	Inc
35	0.9771	-	**70**	1	Swing

After optimal capacitor placement method, it is seen that the voltage profile is improved. Now, all bus voltages have value more than 0.97 pu.

VI. CONCLUSION

The work has been carried out to find the optimal tie switches and sizes (KVAr) of capacitors in radial distribution system to minimize the losses and to improve the voltages of each bus. The above problem has been solved in two step methodology, first the feeder reconfiguration method is applied on the system and find out the exact location of tie switches which has to be opened. Second, after FR the exact location of capacitor bank is identified. By using both of the method a system has minimum loss configuration.

The proposed method was tested on distribution system IEEE 70 buses. In the 70-bus system it was found that by opening 11 switches and placing a total 2.0 MVAr optimal capacitors bank at 9 different locations, the loss can be reduced from 179 KW to 135KW. This will also help in improving the bus voltages.

From the study the following conclusions are drawn.

(i) The compensation is yielding into increase in voltage profile, reduction in losses.

(ii) The developed algorithm is effective in deciding the tie switches and allocation of capacitors.

VII. REFERENCES

[1] Merlin and H. Back, 'Search for a Minimal-Loss Operating Spanning Tree Configuration in Urban Power Distribution Systems", *Proc. of 5th Power Systems Comp. Con.*, Cambridge, U. K., Sept. 1-5, 1975.

[2] D. Shirmohammadi and H. W. Hong, "Reconfiguration of electric distribution networks for resistive losses reduction," *IEEE Trans. Power Delivery*, vol. 4, pp. 1402–1498, Apr. 1989.

[3] G. J. Peponis, M. P. Papadopoulos, and N. D. Hatziargyriou, "Optimal operation of distribution networks," *IEEE Trans. Power Syst.*, vol. 11, no. 1, pp. 59–67, Feb. 1996.

[4] H. P. Schmidt, N. Ida, N. Kagan, and J. C. Guaraldo, "Fast reconfiguration of distribution systems considering loss minimization," *IEEE Trans. Power Syst.*, vol. 20, no. 3, pp. 1311–1319, Aug. 2005.

[5] R. P. Broadwater, A. H. Khan, H. E. Shaalan, and R. E. Lee, "Time varying load analysis to reduce distribution losses through reconfiguration," *IEEE Trans. Power Del.*, vol. 8, no. 1, pp. 294–300, Jan. 1993.

[6] B. Morton and I. M. Mareels, “An efficient brute-force solution to the network reconfiguration problem,” *IEEE Trans. Power Syst*., vol. 15, no. 3, pp. 996–1000, Aug. 2000.

[7] M.W. Siti, D.V..Nicolae, A.A. Jimoh,and A. Ukil, “Reconfiguration and Load Balancing in the LV and MV Distribution Networks for Optimal Performance” *IEEE Trans. On Power Delivery*, Vol. 22, No. 4, Oct 2007

[8] G. K. Viswanadha Raju, and P. R. Bijwe , “An Efficient Algorithm for Minimum Loss Reconfiguration of Distribution System Based on Sensitivity and Heuristics” *IEEE Trans. On Power Systems*, Vol. 23, No.3, Aug. 2008

[9] S.K. Salman, “The Impact of Embedded Generation on Voltage Regulation and Losses of Distribution Networks”, *IEE Colloquium on the Impact of Embedded Generation on Distribution Networks* (Digest No. 1996/194), 15 Oct. 1996, pp. 2/1 – 2/5.

[10] C.L.T Borges, and D.M. Falcao, “Impact of Distributed Generation Allocation and Sizing on Reliability, Losses, and Voltage Profile”, 2003 *IEEE Bologna Power Tech Conference Proceedings*, Bologna, 23-26 June 2003, Vol. 2.

[11] I.E. Davidson, and N.M. Ijumba, “Optimization Model for Loss Minimization in a Deregulated Power Distribution Network”, 6th *IEEE Africon Conference in Africa (AFRICON), Africa*, 2-4 Oct. 2002, Vol.2, pp.887 – 894.

[12] T. Griffin, K. Tomsovic, D. Secrest, and A. Law, “Placement of Dispersed Generations for Reduced Losses”, *Proceedings of the 33rd Annual Hawaii International Conference on System Sciences*, 2000, 4-7 Jan., 2000.

[13] J. Mutale, G. Strbac, S. Curcic, and N. Jenkins, “Allocation of Losses in Distribution Systems with Embedded Generation”, *IEE Proceedings of Generation, Transmission and Distribution*, Jan. 2000, Vol. 147, Issue 1, pp. 7 – 14.

[14] M.A. Kashem, D.T.M. Negnevitsky, and G. Ledwich, “Distributed Generation for Minimization of Power Losses in Distribution Systems” *IEEE Power Engineering Society General Meeting*, June 2006, pp. 8-14.

[15] X. P. Zhang , “Energy Loss Minimization of Electricity Networks with Large Wind Generation using FACTS” *IEEE Power and Energy Society General Meeting - Conversion and Delivery of Electrical Energy in the 21st Century*, July 2008 ,pp. 1-5.

[16] W.Lin, Y.Sheng, S.Chien, M.Tsay, S.Chen, “The Optimal Loss Reduction of Distribution Feeder Based on Special Distribution Transformers Reconnect ion Using Genetic Algorithm” Power System Technology, 2000. Proceedings *IEEE PowerCon 2000*, Volume 3, 4-7 Dec. 2000 pp. 1413 – 1418.

[17] M.S.Tsai,F.Y.Hsu ,“ Comparison of Genetic Algorithm Reproduction Methods for Distribution System Loss Minimization” *Proceedings of the Third IEEE International Conference on’ Machine Learning and Cybemetics*, Shanghai, 26-29 August 2004

[18] A.Augugliaro, L.Dusonchet, S.Favuzza, and E.R.Sanseverino, “Voltage Regulation and Power Losses Minimization in Automated Distribution Networks by an Evolutionary Multiobjective Approach” *IEEE Transactions on Power Systems*, vol. 19, no. 3, august 2004

[19] K. Amaresh, S. Sivanagaraju, and V. Sankar, “Minimization of Losses in Radial Distribution System by using HVDS” *IEEE Power Electronics, Drives and Energy Systems*, *2006. PEDES '06.*, International Conference on 12-15 Dec. 2006 pp.1 - 5

[20] T. M. Khalil, G. M. Omar A. A. Sallam, “Power Losses Minimization and Voltage Profile Enhancement for Distribution Feeders using PSO” *IEEE Power Engineering, 2007* Large Engineering Systems Conference on 10-12 Oct. 2007 pp. 101 – 105

[21] Sirous Badali ,“Distribution Feeder Reconfiguration for Deviation Bus Voltage Minimization Based on Modified Honey Bee Mating Optimization Algorithm” *European Journal of Scientific Research* ISSN 1450-216X Vol.71 No.3 (2012), pp. 338-346

[22] Debapriya Das, “A fuzzy multiobjective approach for network reconfiguration of distribution systems”, *IEEE Trans. Power Del.* , vol. 21 no.1 pp. 202-209, Jan 2006.

APPENDIX A

TABLE VI

LINE DATA AND LOAD DATA OF 70 BUS RADIAL DISTRIBUTION

Br. No	Send. End Bus	Recv. End Bus	R(Ohm)	X(Ohm)	PL (KW)	QL (KVAr)
1	1	2	1.097	1.074	100.0	90.0
2	2	3	1.463	1.432	60.0	40.0
3	3	4	0.731	0.716	150.0	130.0
4	4	5	0.366	0.358	75.0	50.0
5	5	6	1.828	1.790	15.0	9.0
6	6	7	1.097	1.074	18.0	14.0
7	7	8	0.731	0.716	16.0	11.0
8	8	9	0.731	0.716	16.0	11.0
9	9	10	1.080	0.734	20.0	10.0
10	10	11	1.620	1.101	16.0	9.0
11	11	12	1.080	0.734	50.0	40.0
12	12	13	1.350	0.917	105.0	90.0
13	13	14	0.810	0.550	25.0	15.0
14	14	15	1.944	1.321	40.0	25.0
15	7	68	1.080	0.734	100.0	60.0
16	68	69	1.620	1.101	40.0	30.0
17	1	16	1.097	1.074	60.0	30.0
18	16	17	0.366	0.358	40.0	25.0
19	17	18	1.463	1.432	15.0	9.0
20	18	19	0.914	0.895	13.0	7.0
21	19	20	0.804	0.787	30.0	20.0
22	20	21	1.133	1.110	90.0	50.0
23	21	22	0.475	0.465	50.0	30.0
24	17	23	2.214	1.505	60.0	40.0
25	23	24	1.620	1.110	100.0	80.0
26	24	25	1.080	0.734	80.0	65.0
27	25	26	0.540	0.367	100.0	60.0
28	26	27	0.540	0.367	100.0	55.0
29	27	28	1.080	0.734	120.0	70.0
30	28	29	1.080	0.734	105.0	70.0
31	70	30	0.366	0.358	80.0	50.0
32	30	31	0.731	0.716	60.0	40.0
33	31	32	0.731	0.716	13.0	8.0
34	32	33	0.804	0.787	16.0	9.0
35	33	34	1.170	1.145	50.0	30.0
36	34	35	0.768	0.752	40.0	28.0
37	35	36	0.731	0.716	60.0	40.0
38	36	37	1.097	1.074	40.0	30.0
39	37	38	1.463	1.432	30.0	25.0
40	32	39	1.080	0.734	150.0	100.0
41	39	40	0.540	0.367	60.0	35.0
42	40	41	1.080	0.734	120.0	70.0
43	41	42	1.836	1.24	90.0	60.0

44	42	43	1.296	0.881	18.0	10.0
45	40	44	1.188	0.807	16.0	10.0
46	44	45	0.540	0.367	100.0	50.0
47	42	46	1.080	0.734	60.0	40.0
48	35	47	0.540	0.367	90.0	70.0
49	47	48	1.080	0.734	85.0	55.0
50	48	49	1.080	0.734	100.0	70.0
51	49	50	1.080	0.734	140.0	90.0
52	70	51	0.366	0.358	60.0	40.0
53	51	52	1.463	1.432	20.0	11.0
54	52	53	1.463	1.432	40.0	30.0
55	53	54	0.914	0.895	36.0	24.0
56	54	55	1.097	1.074	30.0	20.0
57	55	56	1.097	1.074	43.0	30.0
58	52	57	0.270	0.183	80.0	50.0
59	57	58	0.270	0.183	240.0	120.0
60	58	59	0.810	0.550	125.0	110.0
61	59	60	1.296	0.881	25.0	10.0
62	55	61	1.188	0.807	10.0	5.0
63	61	62	1.188	0.807	150.0	130.0
64	62	63	0.810	0.550	50.0	30.0
65	63	64	1.620	1.101	30.0	20.0
66	62	65	1.080	0.734	130.0	120.0
67	65	66	0.540	0.367	150.0	130.0
68	66	67	1.080	0.734	25.0	15.0
69	9	50	0.908	0.726	-	-
70	9	38	0.381	0.244	-	-
71	15	46	0.681	0.544	-	-
72	22	67	0.254	0.203	-	-
73	29	64	0.254	0.203	-	-
74	45	60	0.254	0.203	-	-
75	43	38	0.454	0.203	-	-
76	39	59	0.454	0.363	-	-
77	21	27	0.454	0.363	-	-
78	15	9	0.681	0.544	-	-
79	67	15	0.454	0.363	-	-