RADIAL CONFIGURATION OF RING MAIN DISTRIBUTION SYSTEM USING LEAST APPARENT POWER FLOW METHOD

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Abstract— The research work provides an idea of converting ring main network to a radial system by using least apparent power flow methodology through network line switching. In the proposed study successive load flow results on IEEE 33 Bus Test system provides the power flow data of each lines of the system. The high impedance network lines are determined and sorted out by the switching of breaker from the utility side. Load should not be curtailed in any amount & it must be managed from multiple connectivity paths available. The power to the load end is provided by least impedance path which is identified from load flow studies. This method is suitable for large bus system having higher number of buses & which can't be operated in a ring system due to problems of improper co-ordination, high fault current and network congestion management issues. Therefore it is advised to implement least apparent power flow method for obtaining a radial system instead of utilizing meshed complicated network in a power system.

Index Terms— least apparent power flow, load balancing, network switching, optimal distribution network, Radial network.

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1   INTRODUCTION

The distribution of power with reduced losses have always been a difficult task for grid operators. Since the growth & demands of power supply can't be judged and providing a quality power supply always needs proper planning & studies of the system. Time factor is also a consideration from equipment side as well as operating period point of view. An algorithm has been proposed, which is capable of analyzing the system & can perform power flow studies. IEEE 33 Bus system has been used for implementation of technique of minimum apparent power flow by network switching operation. The network lines are provided with tie and sectionalizing switches or the breakers by switching them the operators are capable of connecting or disconnecting any line as per situations prevailing. The studies presented here consist of a distribution system (IEEE 33 Bus) modeled in Mi-Power software. The load flow studies of the system determines the system losses and practices are being performed to provide a considerable savings in energy as well as maintaining of voltage profile of network for maintaining improved grid operations.

2. OBJECTIVES OF RESEARCH STUDIES

Network switching is performed by opening and closing of the line switches. The feeder is being served from multiple connectivity paths and radiality of the network is being maintained. Taking the context of loss reduction and obtaining a radial pattern of power flow the paper aims to determine the applicability of proposed algorithm for a large scale distribution network too. Thus considering a network switching strategy to be performed the following objective are to be discussed thoroughly in the paper:

I.   Determining a radial power flow network utilizing proposed technique on a ring main network.

II.   Calculating the total system losses including both active and reactive power losses.

III.   Identification of least MVA power flow lines to reduce network losses.

3 TEST SYSTEM DESCRIPTIONS

The Ring main distribution system of IEEE 33 Bus network has been modeled and simulated by using Mi-Power software. The Test system consists of a standard IEEE 33 Bus arrangement. The transmission lines are switched by changing breaker status of both the ends. The multiple connectivity paths are also shown which can be used as precaution during a system contingency. The load flow study results considering the ring network by using fast decoupled load flow is displayed in the Fig. 1.
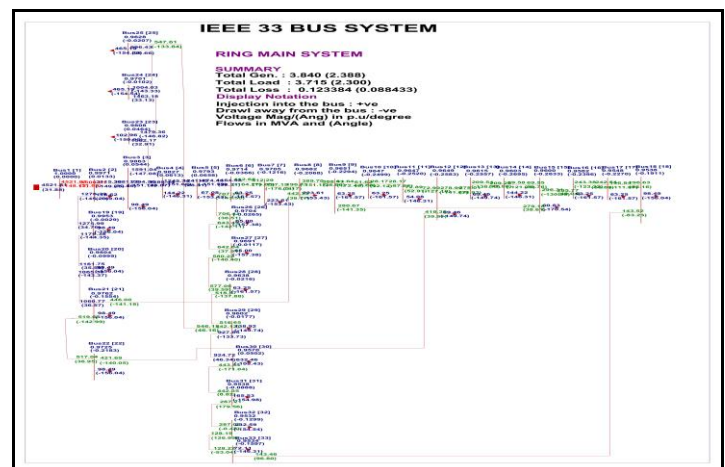

Fig-1: IEEE 33 Bus System Modeling Diagram in Mi-Power Software

4 IMPLEMENTATION OF LEAST APPARENT POWER FLOW METHOD (LAPF)

The proposed LAPF technique results in providing a new radial pattern of power distribution. The set of network switches are also determined which are responsible for providing the multiple connectivity paths to all other feeders. During the simulation studies it must be checked as a major constraint that no load should be curtailed along with the maintaining of system voltage profile and current regulations in their limits. All precautions must be looked carefully to avoid any down fall in the system.The network line switching is carried out by running successive load flow studies and identification of network lines as per the minimum apparent power flow. The complete methodology followed is carried out in few certain governing steps by which the system takes the input and provides an optimal output configuration for optimal power flow distribution.

The algorithm steps are clarified further by the steps provided below and then followed by the flowchart determining the sequence.

Step 1: Perform Load Flow Analysis (LFA) and obtained the total losses of Ring main network.

Step 2: Identify the minimum apparent power flow network line and sort out for switching action. Essentially check the conditions that no amount of load should be curtailed and system voltage and current must be under its min-max limit (.90PU to 1.0 PU).

Step 3: Now LFA is performed again to determine system losses and the next network distribution line having minimum apparent power flow. Afterwards system min-max limits are to be checked at each stage.

Step 4: Similarly above steps are repeated till the system becomes radial. Then final network obtained is the system having minimum losses.

Thus new pattern of power flow is obtained which has the optimal power flow conditions and fulfilled major constraints. The algorithm steps provide the flow of operation performed & is indicated in the figure no.2.

The flowchart illustrates the background flow performed by a utility during the implementation of suggested optimization technique. The efficiency of working out of the algorithm determines the system efficeiency obtained from the whole operations. The coordinated work of each & every equipment is responsible for obtaining a sytem having reduced losses. The algorithm & flowchart explained in figure 2 determines the mechanism of technique implemented.
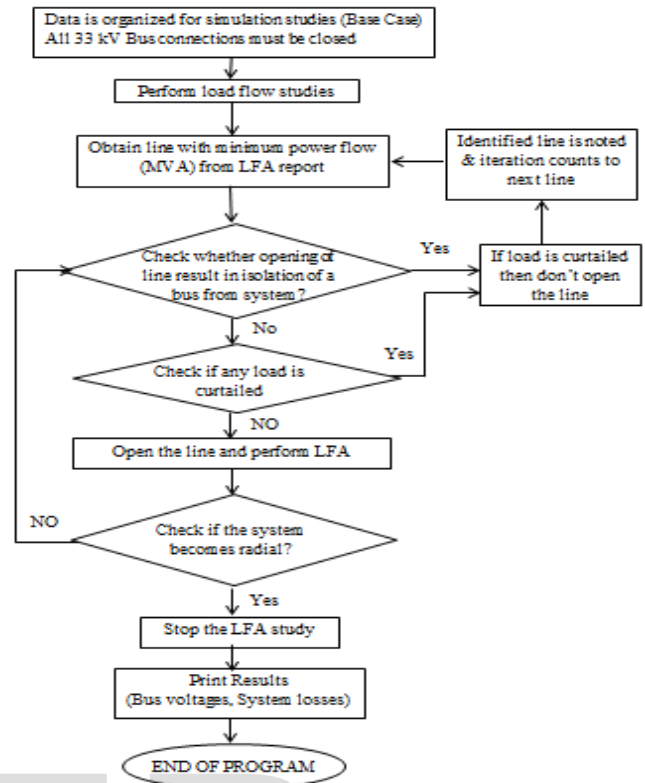

Fig. 2- Flowchart of Proposed Technique

5 SIMULATION STUDIES AND OUTPUTS

The modeling of different components to obtain a co-ordinated test system is performed in Mi-Power software Afterwards the technique is deployed as per the algorithm suggestions. The simulation studies are divided into five different cases. In each case the LFA is performed and network line is switched. After the simulation studies the final network obtained is the radial pattern. The reduction of losses and line identification is illustrated with case diagrams of test system in the following sections.

CASE-1: Switch Opening Between Bus No. 33 & Bus No. 18.

In this case network line between bus no 33 & 18 is opened by the utility. During simulation results a minimum percentage loading of 0.004 is being obtained which is providing a total loss of 0.124560.

Fig.3 Test System Simulation Diagram of Case 3 in Mi-Power Software

CASE-2: Switch Opening Between Bus No. 9 & Bus No. 15.

In this case network line between bus no 9 & 15 is opened by the utility. During simulation results a minimum percentage loading of 0.007 is being obtained which is providing a total loss of 0.127058.

Fig.4 Test System Simulation Diagram of Case 2 in Mi-Power Software

CASE-3: Switch Opening Between Bus No. 8 & Bus No. 21.

In this case network line between bus no 8 & 21 is opened by the utility. During simulation results a minimum percentage loading of 0.010 is being obtained which is providing a total loss of 0.133475.
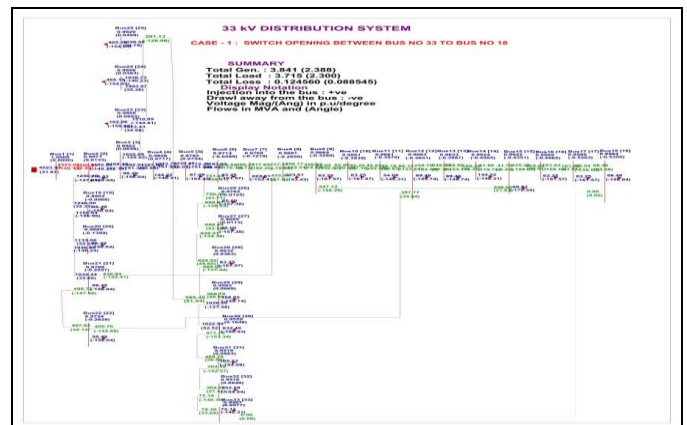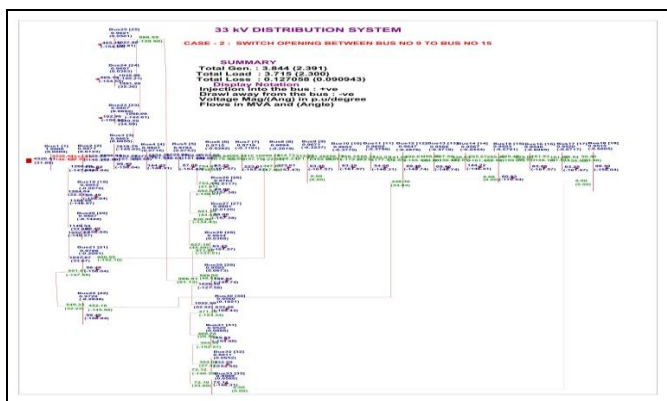

Fig. 5 Test System Simulation Diagram of Case 3 in Mi-Power Software

CASE-4: Switch Opening Between Bus No. 25 & Bus No. 29.

In this case network line between bus no 25 & 29 is opened by the utility. During simulation results a minimum percentage loading of 0.016 is being obtained which is providing a total loss of 0.153961.
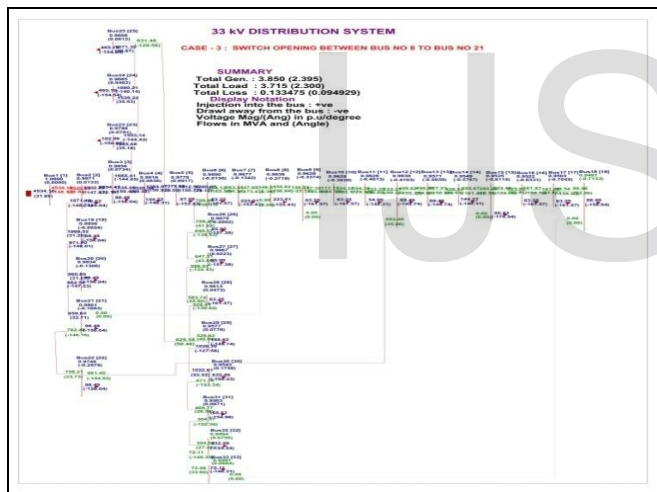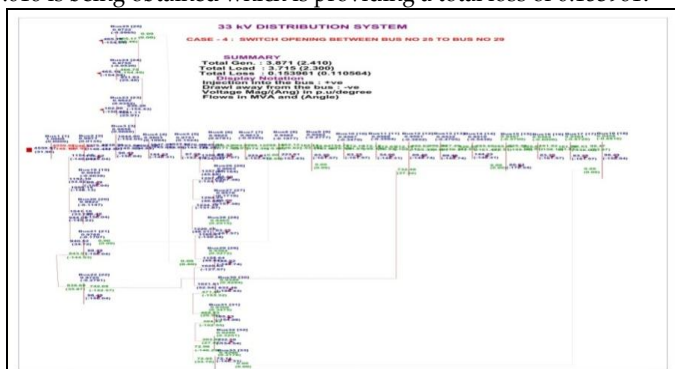

Fig. 6 Test System Simulation Diagram of Case 4 in Mi-Power Software

CASE-5: Switch Opening Between Bus No. 22& Bus No. 12.

In this case network line between bus no 22& 12 is opened by the utility. During simulation results a minimum percentage loading of 0.018 is being obtained which is providing a total loss of 0.210916.
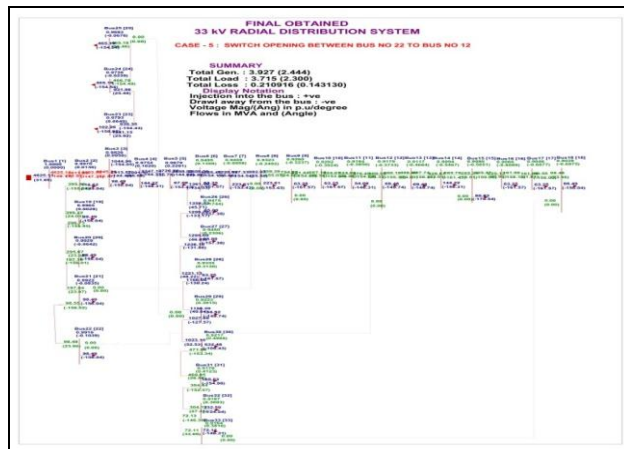
Fig. 7 Test System Simulation Diagram of Case 5 in Mi-Power Software

6 COMPARISION OF NETWORK SWITCHING METHODOLOGY

A ring main distribution network can be made radial either by randomly opening of lines or by the implementation of an optimal algorithm. These algorithms are results of conceptual analysis & various research practices which aim to achieve an optimal solution. The IEEE 33 kV Bus system is made to operate radially by considering random operation of network line (termed as analysis -1) & then later by the implementation of least apparent power flow methodology (termed as analysis - 2). The comparative analysis is presented in the following sub sections.

    I.   Analysis 1 Radial configuration through random Switching

The IEEE 33 Bus ring main distribution system is made radial by random opening of network lines. The simulation study results are provided in figure 8 and the identity of lines opened along with total system losses are provided in Table 1.

Fig. 8 Test System Simulation Diagram of Case 4 in Mi-Power Software

    II.   Analysis 2 Radial configuration through LAPF Technique

The IEEE 33 Bus ring main distribution system is made radial by im-

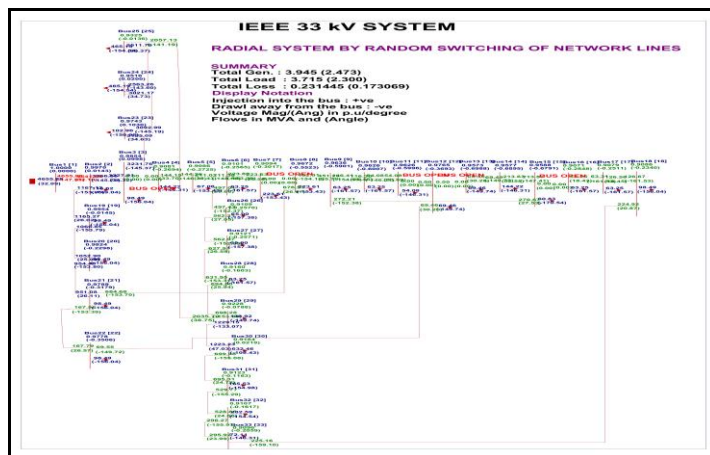International Journal of Scientific & Engineering Research, Volume 6, Issue , May-2015

plementation of LAPF technique and then as per the algorithm processed the switching action is performed to obtain a radial pattern of power flow. The simulation study results are provided in Figure 9 and the identity of lines opened along with total system losses are provided in Table 1
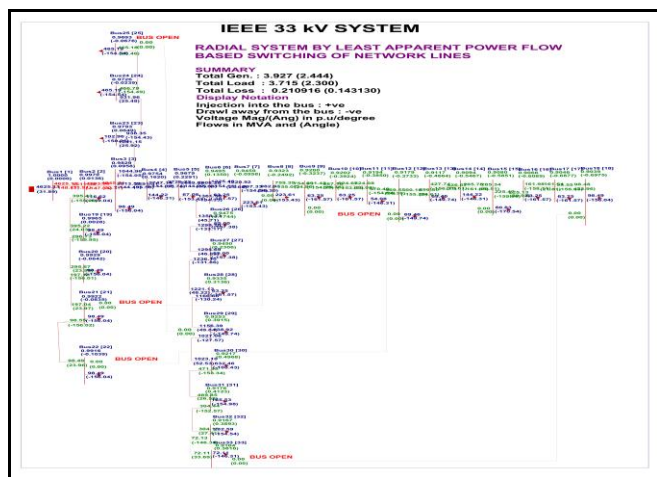

Fig. 9 Test System Simulation Diagram of Case 4 in Mi-Power Software

The results of load flow studies for Analysis1 and Analysis 2 is presented in table 1.

TABLE 1
Comparision of Switching Technique

Parameters.	Analysis 1	Analysis 2
Buses opened	3-4,7-8, 11-12, 12-13, 15-16	8-21, 10-11, 9-15, 22-12, 33-18
Total System Loses	0.231445	0.210916

The obtained results concludes that tha amount of reduction in losses can be better obtained by the utilization of least apparent power flow technique .The reduction in losses obtained by proposed research methodology will deliberately raised up with the increase in size of system too. Hence it can also be tested and implemented for a distribution system having greater than 100 node points.

7 CONCLUSION & FUTURE SCOPE

1. The radial 33 kV distribution system with reduced losses has been obtained
2. The system voltage profile has been improved with reduction in lines loading.
3. Radial operation by network switching utilizing LAPF technique is suggested to be a better way of converting a ring main network.

This methodology is applicable for larger size network also since it takes a holistic view of every single network lines one by one.The power flows are checked at each stage while avoiding any in-between contingencies. The technique can be easily de ployed without providing much Information Technology Architecture & without purchasing any new equipment set up's hence it can be termed to be more compatible and acceptable way of achieving a radial set up for the existing ring main set up.

REFERENCE

[1] A.Merlin and H.Back, "Search for a minimal loss operating spanning tree configuration in an urban power distribution system", in Proc. 5th Power System Computation Conference (PSCC), 1975.

[2] D.S.mohammadi and H. Hong, "Reconfiguration of electric distribution networks for   resistive line losses reduction", IEEE Trans. Power Deliv., vol. 4, no. 2, pp. 1492–1498, Apr. 1989.

[3] Simulation software Mi-Power available at PRDC, Banglore http://www.prdcinfotech.com/products.html

Appendix-1

BUS DATA FOLLOWS

 1 Bus1   1 1 3 1.00 0.00   0.00   0.00 120.00 74.98 12.660 1.000
1.050 0.950   0.00   0.00   0

 2 Bus2   1 1 0 1.00 0.00   0.10   0.06   0.00 0.00 12.660 1.000
1.050 0.950   0.00   0.00   0

 3 Bus3   1 1 0 1.00 0.00   0.09   0.04   0.00 0.00 12.660 1.000
1.050 0.950   0.00   0.00   0

 4 Bus4   1 1 0 1.00 0.00   0.12   0.08   0.00 0.00 12.660 1.000
1.050 0.950   0.00   0.00   0

 5 Bus5   1 1 0 1.00 0.00   0.06   0.03   0.00 0.00 12.660 1.000
1.050 0.950   0.00   0.00   0

 6 Bus6   1 1 0 1.00 0.00   0.06   0.02   0.00 0.00 12.660 1.000
1.050 0.950   0.00   0.00   0

 7 Bus7   1 1 0 1.00 0.00   0.20   0.10   0.00 0.00 12.660 1.000
1.050 0.950   0.00   0.00   0

 8 Bus8   1 1 0 1.00 0.00   0.20   0.10   0.00 0.00 12.660 1.000
1.050 0.950   0.00   0.00   0

 9 Bus9   1 1 0 1.00 0.00   0.06   0.02   0.00 0.00 12.660 1.000
1.050 0.950   0.00   0.00   0

10 Bus10   1 1 0 1.00 0.00   0.06   0.02   0.00 0.00 12.660 1.000
1.050 0.950   0.00   0.00   0

11 Bus11   1 1 0 1.00 0.00   0.05   0.03   0.00 0.00 12.660 1.000
1.050 0.950   0.00   0.00   0

12 Bus12   1 1 0 1.00 0.00   0.06   0.04   0.00 0.00 12.660 1.000
1.050 0.950   0.00   0.00   0

13 Bus13   1 1 0 1.00 0.00   0.06   0.04   0.00 0.00 12.660 1.000
1.050 0.950   0.00   0.00   0

14 Bus14   1 1 0 1.00 0.00   0.12   0.08   0.00 0.00 12.660 1.000
1.050 0.950   0.00   0.00   0

15 Bus15   1 1 0 1.00 0.00   0.06   0.01   0.00 0.00 12.660 1.000
1.050 0.950   0.00   0.00   0

16 Bus16   1 1 0 1.00 0.00   0.06   0.02   0.00 0.00 12.660 1.000
1.050 0.950   0.00   0.00   0

17 Bus17   1 1 0 1.00 0.00   0.06   0.02   0.00 0.00 12.660 1.000
1.050 0.950   0.00   0.00   0

18 Bus18   1 1 0 1.00 0.00   0.09   0.04   0.00 0.00 12.660 1.000
1.050 0.950   0.00   0.00   0

19 Bus19   1 1 0 1.00 0.00   0.09   0.04   0.00 0.00 12.660 1.000
1.050 0.950   0.00   0.00   0

20 Bus20   1 1 0 1.00 0.00   0.09   0.04   0.00 0.00 12.660 1.000
1.050 0.950   0.00   0.00   0

21 Bus21   1 1 0 1.00 0.00   0.09   0.04   0.00 0.00 12.660 1.000
1.050 0.950   0.00   0.00   0

22 Bus22   1 1 0 1.00 0.00   0.09   0.04   0.00 0.00 12.660 1.000
1.050 0.950   0.00   0.00   0

23 Bus23   1 1 0 1.00 0.00   0.09   0.05   0.00 0.00 12.660 1.000

1.050 0.950   0.00   0.00   0
 24 Bus24   1 1 0 1.00   0.00   0.42   0.20   0.00   0.00 12.660 1.000
1.050 0.950   0.00   0.00   0
 25 Bus25   1 1 0 1.00   0.00   0.42   0.20   0.00   0.00 12.660 1.000
1.050 0.950   0.00   0.00   0
 26 Bus26   1 1 0 1.00   0.00   0.06   0.03   0.00   0.00 12.660 1.000
1.050 0.950   0.00   0.00   0
 27 Bus27   1 1 0 1.00   0.00   0.06   0.03   0.00   0.00 12.660 1.000
1.050 0.950   0.00   0.00   0
 28 Bus28   1 1 0 1.00   0.00   0.06   0.02   0.00   0.00 12.660 1.000
1.050 0.950   0.00   0.00   0
 29 Bus29   1 1 0 1.00   0.00   0.12   0.07   0.00   0.00 12.660 1.000
1.050 0.950   0.00   0.00   0
 30 Bus30   1 1 0 1.00   0.00   0.20   0.60   0.00   0.00 12.660 1.000
1.050 0.950   0.00   0.00   0
 31 Bus31   1 1 0 1.00   0.00   0.15   0.07   0.00   0.00 12.660 1.000
1.050 0.950   0.00   0.00   0
 32 Bus32   1 1 0 1.00   0.00   0.21   0.10   0.00   0.00 12.660 1.000
1.050 0.950   0.00   0.00   0
 33 Bus33   1 1 0 1.00   0.00   0.06   0.04   0.00   0.00 12.660 1.000
1.050 0.950   0.00   0.00   0
-999
BRANCH DATA FOLLOWS
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0.000 0.000 0.0000   0.00   0.00
  3   4 1 1 1 0 0.22836   0.11630   0.00003   3   3   0 0 0.000   0.00
0.000 0.000 0.0000   0.00   0.00
  4   5 1 1 1 0 0.23778   0.12110   0.00003   3   3   0 0 0.000   0.00
0.000 0.000 0.0000   0.00   0.00
  5   6 1 1 1 0 0.51099   0.44112   0.00003   3   3   0 0 0.000   0.00
0.000 0.000 0.0000   0.00   0.00
  6   7 1 1 1 0 0.11680   0.38484   0.00003   3   3   0 0 0.000   0.00
0.000 0.000 0.0000   0.00   0.00
  7   8 1 1 1 0 1.06779   0.77061   0.00003   3   3   0 0 0.000   0.00
0.000 0.000 0.0000   0.00   0.00
  8   9 1 1 1 0 0.64264   0.46170   0.00003   3   3   0 0 0.000   0.00
0.000 0.000 0.0000   0.00   0.00
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0.000 0.000 0.0000   0.00   0.00
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0.000 0.000 0.0000   0.00   0.00
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0.000 0.000 0.0000   0.00   0.00
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0.000 0.000 0.0000   0.00   0.00
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 19 20 1 1 1 0 0.93851   0.84567   0.00003   3   3   0 0 0.000   0.00
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 20 21 1 1 1 0 0.25550   0.29849   0.00003   3   3   0 0 0.000   0.00
0.000 0.000 0.0000   0.00   0.00
 21 22 1 1 1 0 0.44230   0.58481   0.00003   3   3   0 0 0.000   0.00
0.000 0.000 0.0000   0.00   0.00
  3 23 1 1 1 0 0.28152   0.19236   0.00003   3   3   0 0 0.000   0.00
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0.000 0.000 0.0000   0.00   0.00
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0.000 0.000 0.0000   0.00   0.00
 29 30 1 1 1 0 0.31664   0.16128   0.00003   3   3   0 0 0.000   0.00
0.000 0.000 0.0000   0.00   0.00
 30 31 1 1 1 0 0.60795   0.60084   0.00003   3   3   0 0 0.000   0.00
0.000 0.000 0.0000   0.00   0.00
 31 32 1 1 1 0 0.19373   0.22580   0.00003   3   3   0 0 0.000   0.00
0.000 0.000 0.0000   0.00   0.00
 32 33 1 1 1 0 0.21276   0.33081   0.00003   3   3   0 0 0.000   0.00
0.000 0.000 0.0000   0.00   0.00
  8 21 1 1 1 0 1.24785   1.24785   0.00004192 4192 4192   0 0 0.000
0.00   0.000 0.000 0.0000   0.00   0.00
  9 15 1 1 1 0 1.24785   1.24785   0.00004192 4192 4192   0 0 0.000
0.00   0.000 0.000 0.0000   0.00   0.00
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0.00   0.000 0.000 0.0000   0.00   0.00
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0.00   0.000 0.000 0.0000   0.00   0.00
 25 29 1 1 1 0 0.31196   0.31196   0.00004192 4192 4192   0 0 0.000
0.00   0.000 0.000 0.0000   0.00   0.00
-999