Evaluation of String Efficiency and Voltage Distribution of 400 KV over a String of Glass Suspension-Type Insulator in Different Atmospheric Condition

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Abstract— an electric power transmission cannot be successful unless it is able to deliver uninterrupted power. Continuous operation, so far as the transmission line is concerned, depends largely upon the effectiveness of the insulator which is employed Insulators must, therefore, be obtained. which will not fail in service and this can be only achieved by the testing. For high voltage a string of suspension insulator is used on the basis of voltage of the line number of insulator are decided. In this paper for caculation of string efficiency and voltage distribution of 400 kv with or without guard ring in different atmospheric condition, with 18 string glass suspension type of Insulatorare used.

Key words: Glass Suspension-type Insulator, Polymer Insulator, pin type insulator

I. INTRODUCTION

In recent years, the demand of electrical power has been increased to a large extent. To satisfy this demand, electrical companies have had to improve the efficiency of their transmission lines. The efficiency of the system is based mainly on the continuity of the service, avoiding faults that suppose economical losses for companies and users. To maintain this continuity, one of the main problems that have been found is the failure of insulators of electric lines due to polluted environment. This pollution is one of the main causes of flashover in the insulators. The insulator begins to fail when the pollutants that exist in the air settle in the surface of the insulator and combine with the humidity of the fog, rain, or dew. The mixture of pollutants and the humidity form a layer that can become conductive and allow passing currents that will facilitate the conditions of short circuit. This is due to the decrease of resistance of the insulator surface. Insulators for overhead lines are considered to be of basic importance to the transmission system, through their ability to insulate the power lines as well as their function in carrying the weight of the line conductor.[1] Outdoor insulation is polluted by natural or industrial pollution (sea salt, salt sands, industrial dust). Additional sources of pollution are rain (e.g. acid rains) and gases—especially sulphuric oxide and nitric oxide (SO, NO). With heavily polluted areas the surface conductivity on insulators can exceed which leads to arcing development and eventually to flashover at continuous operating voltage. For giving support and providing insulation for overhead line Conductors against the highest voltage and worst condtition insulators are used. as we know that insulator are not allow to flow current.because of this reason insulator are used for isolation between conductor to conductor and condctor to ground. Commonly porcelain glass and polymer material are used in designing of insulator. Suspension insulator are consist of number of insulator unit or disc connected in series by metal ring in the form of string each unit is normally designed for a low voltage 11 kv Suspension type insulator.

A. Advantage of suspension type insulator over pin type insulator:

1) Each insulator is designed for 11 kv and hence for any operating voltage a string of insulators can be used.
2) In case of failure of one of the units in the string only that particular unit needs replace ment rather than the whole string.
3) Since the power conductor and string swing together in case of wind pressure the mechanical stresses at that point of attachment are reduced as compared with the pin type of insulator where because of the rigid nature of the attachment faitigue and ultimate brittleness of the wire result. On the basis of voltage number of suspension string insulator s are decided.

B. Types of Insulators:

1) According to material used

1) Porcelain Insulator:-The porcelain is aluminium silicate. The aluminium silicate is mixed with plastic kaolin feldspar and quartz to obtain final hard and glazed porcelain insulator material.
2) Glass Insulator: - Annealed tough glass is used for insulating purpose. It has higher tensile strength compared to porcelain insulator. Glass has very long service life as because mechanical and electrical properties do not be affectd by ageing

2) Advantages of Glass Insulator

1) It has very high dielectric strength compared to porcela in.
2) Its resistivity is also very high.
3) It has higher tensile strength compared to porcelain ins ulator.
4) As it is transparent in nature this not heated up in sunli ght as porcelain.
5) The impurities and air bubble can be easily detected in side the glass insulator body because of its transparenc y.
6) Glass has very long service life as because mechanical and electrical properties do not be affected by ageing.

3) Polymer Insulator:-

In polymer insulator has two parts one is glass fiber reinforced epoxy resin rod shaped core and other is silicon rubber or EPDM made weather sheds Rod shaped core is covered by Weather sheds protect the insulator core from outside environment. The Rod shaped core fixed with hop dip galvanized cast steel made end fittings in fixed with hop dip galvanized cast steel made end fittings both side.

Voltage(kV)	33	66	132	230	400	750
Number of units	3-4	5-7	9-11	14-20	18-21	30-35

Table 1: Number of insulators in suspension string

II. VOLTAGE DISTRIBUTION

In a suspension insulator there are two types of capacitive effect is present. Insulator capacitance is called self-capacitance and capacitance present between metalic pin and tower strucutre is called self-capacitance. If there is a self-capacitance alone then voltage across each unit would have been same. But due to present of shunt capacitance voltage disti bution is not uniform. The disc nearest to the conductor has maximum voltage across it and as we move towards the cross arm the voltage across each disc goes on decreasing. The insulator disc are identical each disc is represented by its self-capacitance C1. C2 is the shunt capacitance. shunt capacitance C2 =m c1 where m is the ratio of shunt capacitance to the self-capacitance.

III. STRINGEFFICIENCY

The coefficient of shearing of voltage in string of insulator is called string efficiency. The units nearest to the line are stressed to their maximum allowable under stress, resulting in a 'waste' of insulating material. The string efficiency is a measure of the utilization of material in the string. [4] String efficiency = voltage across the string/n *(voltage across unit adjacent to the conductor). The line unit is always under the maximum stress. To avoid possibility of puncture of line unit due to excessive stress, efforts are made to have uniform potential distribution. Hence some methods are used to get uniform distribution and higher string efficiency. These methods are,

A. Method of Improveming of String Eficiency & voltage distribution

1) Using larger cross arm -By the using of long cross arm shunt capacitance value can be reduced. Due to the limitations of mechanical strength and economical reason the value of k can be reduced to less than 0.1.
2) By grading of Capacitance -To create equal voltage distribution capacitance of different values are used since value of current increases while going towards line conductor capacitance value also increases in capacitance grading
3) By the use of guard ring;-This method is also called static shielding.in this method the voltage distribution and string efficiency can be improved by using aguard ring surrounding the bottom unit and connected to the line.

IV. EFFECT OF POLLUTION

One of the main problem under which the distribution network is exposed in the environment pollution of its electrical insulation. The particle placed in the insulations are not dangerous in dry weather but the problem arises when the environmental wether is humid rains there is drew fog, and then layer can become conductor. To calculate effect on insulator considering superficial resistance reduction by pollution a parallel resistance is considered between each insulator. This effect showed in this paper by parallel connection of resistance to each capacitor unit

V. SIMULATION MODEL

MATLAB / SIMULINK software is being used for the modelling of this model. Simulink is one of its designing tools which is being used for modelling and simulation of electrical systems in MATLAB software. The complete precise modelling of the circuit along with their mechanism is explained in detail as follows below. Fig.1 shows basic equivalent circuit for string of Glass suspension -type insulators. The portion which is a between the two metal fittings. Thus it forms a capacitor. This is called self-capacitance that is denoted as C1.Fig.1 will consist of 18 self-capacitors in series. If only such self-capacitors exist alone in series, the voltage across them would have been equal and series charging current through them would have been same. But in addition to the self-capacitance, there will be capacitance between each metal fitting and the earth i.e. tower. The air acts as a dielectric, such a capacitance is called , "shunt capacitance" that is denoted as C2.due tue shunt capacitance unequal voltage distribution occurs, as shown in circuit 1 glass suspension –type insulators.

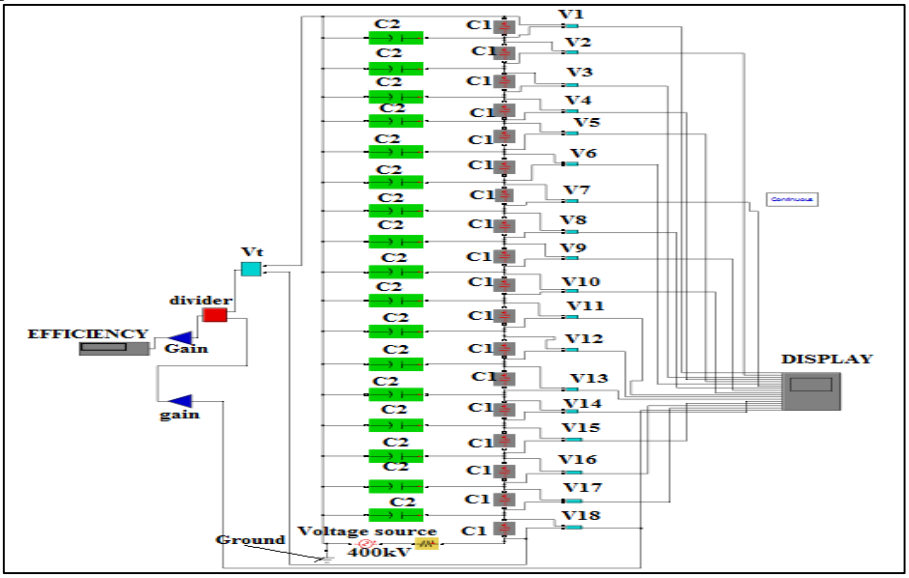


Fig. 1: Equvilent circuit of glass suspension – type insulator without guard rin

As we know that by the use of guard ring string efficiency can be improved. The circuit 2 is designed by Glass suspension -type insulators with guard ring. Fig.2 will consist of 18 self-capacitors in series. If only such self-capacitors exist alone in series, the voltage across them would have been equal and series charging current through them would have been same. But in addition to the self-capacitance, there will be capacitance between each metal fitting and the earth i.e. tower. The air acts as a dielectric, such a capacitance is called, "shunt capacitance" that is denoted as C2, as shown in fig. due toC2, voltage distribution is not uniform and string efficiency is less. By the use of guard ring voltage distribution and string efficiency can be improved. Guard ring is used in this circuit2

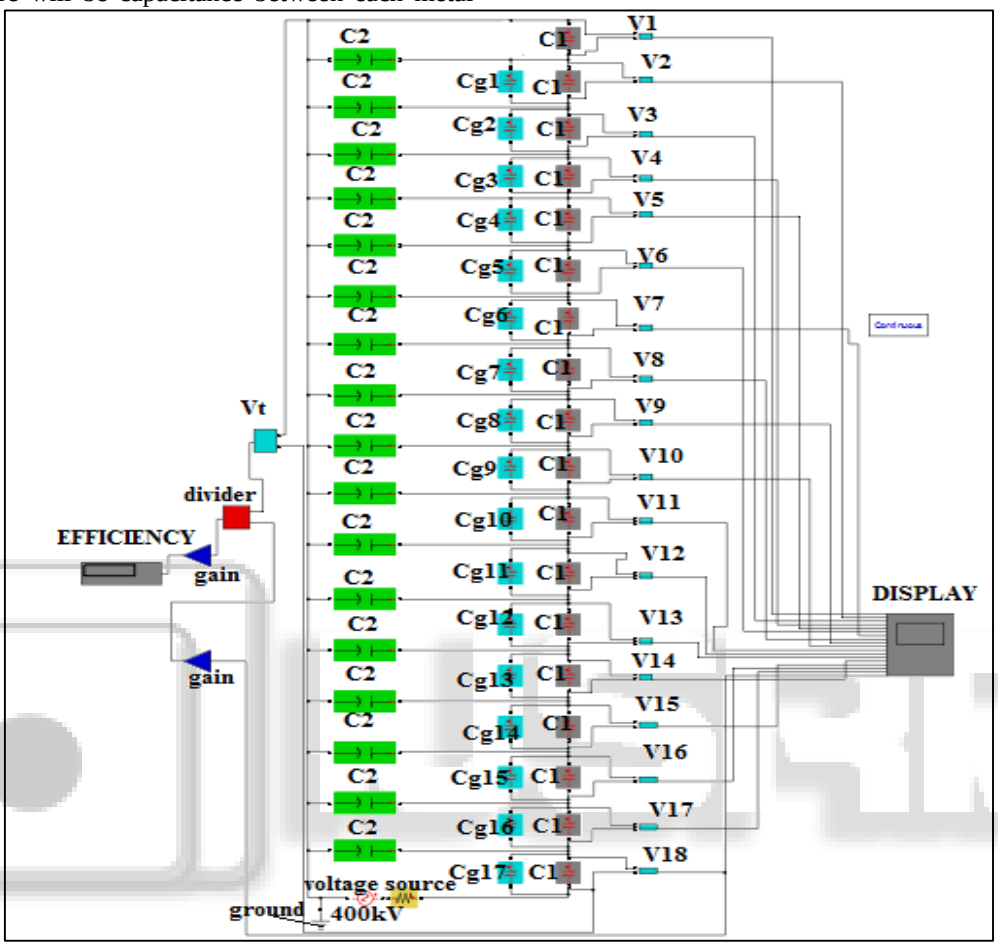


Fig2;-Equvilent circuit of glass suspension-type insulator with guard ring

Circuit 3. Shows atmospheric model for Glass suspension insulators without guard ring for 400kV. Fig.3 shows simulation model of 400k. Glass suspension-type insulator under dust condition (R). To calculate pollution effect on insulation considering resistance reduction by pollution, a parallel resistance is considered between each insulator [7]. R represents values of resistance 5e10, 10e10, 20e10, 40e10 for insulator under dust condition. The values of voltage distribution and efficiency for different values of R (showing amount of dust on glass suspension –type in sulators)

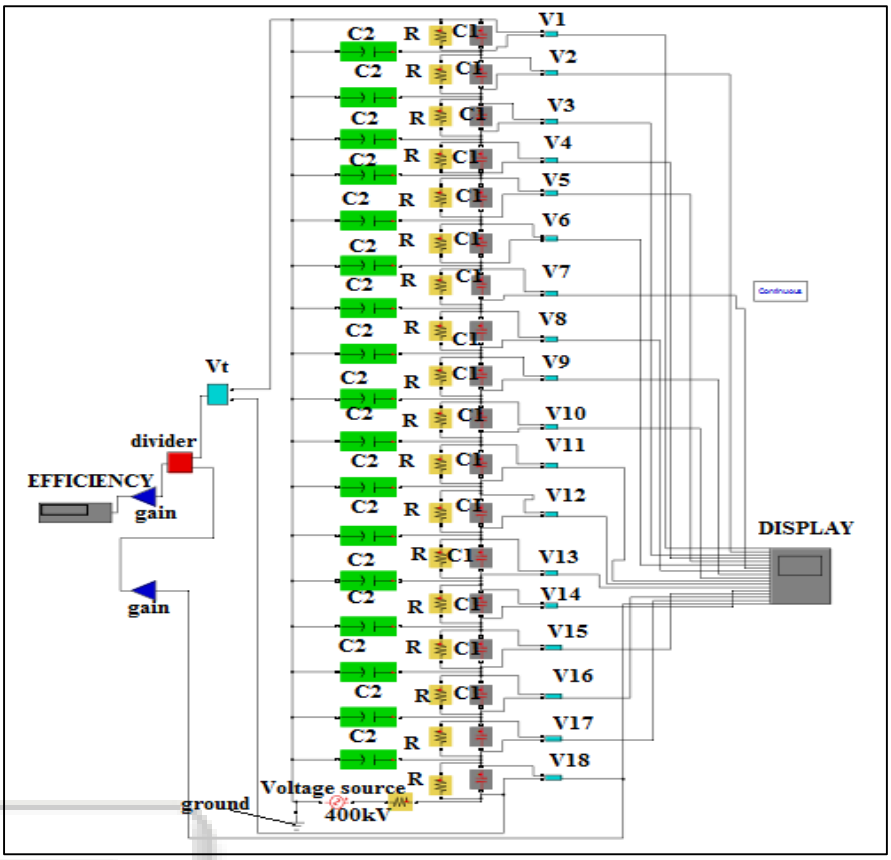


Fig3;-Equvilent circuit of glass suspension- type insulator without guard ring with atmospheric condition

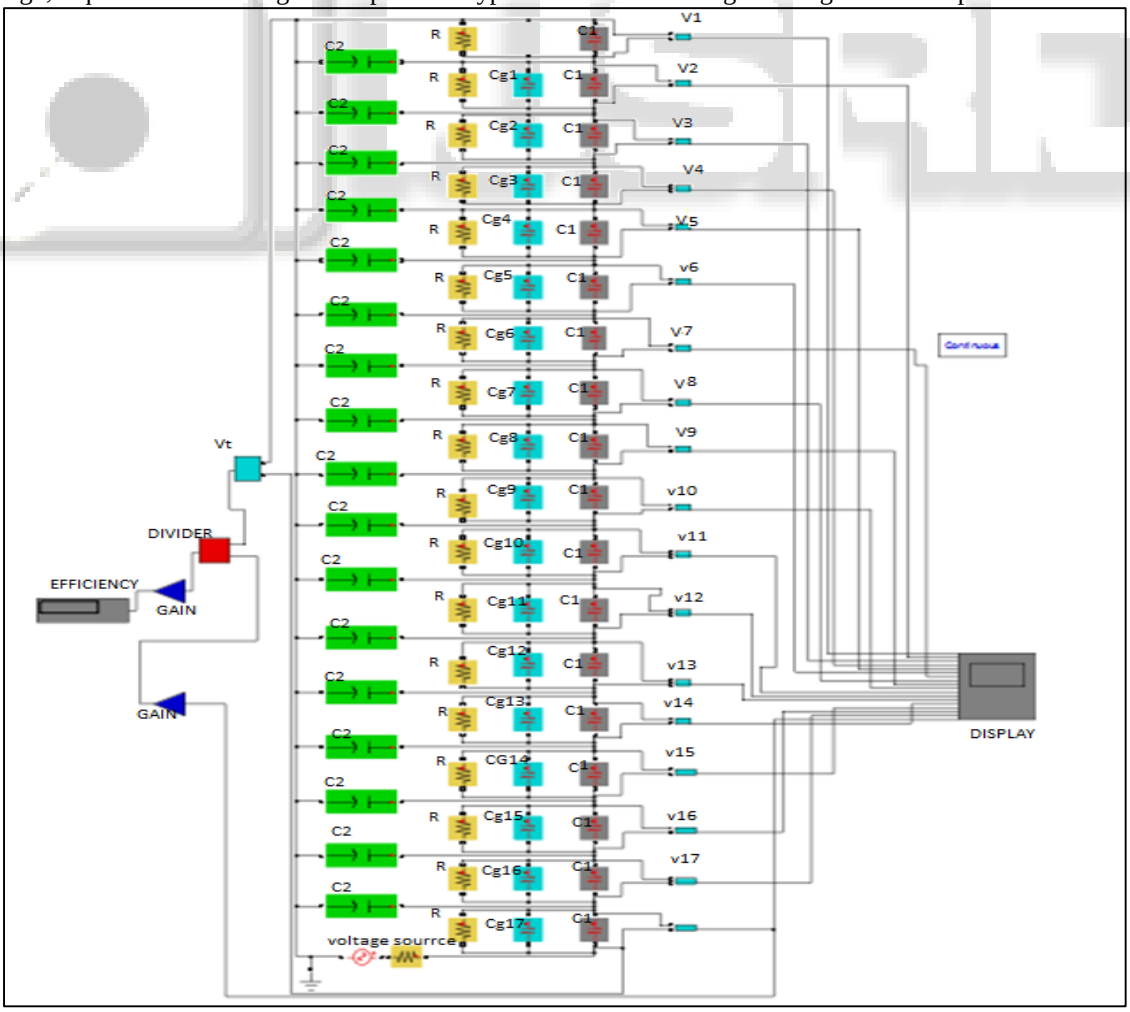


Fig. 4: Equvilent circuit of glass suspension-type insulator with guard ring with atmospheric condition

Circuit4. Shows atmospheric model for Glass suspension insulators with guard ring for 400kV. Fig.4 shows simulation model of 400k. Glass suspension-type insulator under dust condition (R). To calculate pollution effect on insulation considering resistance reduction by pollution, a parallel resistance is considered between each insulator. R represents values of resistance 5e10, 10e10, 20e10, 40e10 for insulator under dust condition. The values of voltage distribution and efficiency for different values of R (showing amount of dust on glass suspension –type insulators)

VI. RESULTS AND DISCUSSION

V1(kV)	V2(kV)	V3(kV)	V4(kV)	V5(kV)	V6(kV)	V7(kV)	V8(kV)	V9(kV)	η(%)
5.90	6.20	6.50	7.00	7.90	8.90	10.00	11.70	13.50	47.95
V10(kV)	V11(kV)	V12(kV)	V13(kV)	V14(kV)	V15(kV)	V16(kV)	V17(kV)	V18(kV)	
15.90	18.50	21.50	25.10	28.20	31.80	33.00	35.80	38.00	

Table 1: Normal Atmospheric Condition for Glass Suspension-Type Insulator without Guard Ring

V1(kV)	V1(kV)	V1(kV)	V1(kV)	V1(kV)	V1(kV)	V1(kV)	V1(kV)	V1(kV)	η(%)
7.80	8.00	8.50	9.05	10.00	11.50	12.50	14.20	16.00	80.95
V1(kV)	V1(kV)	V1(kV)	V1(kV)	V1(kV)	V1(kV)	V1(kV)	V1(kV)	V1(kV)	
18.40	21.00	23.60	26.00	28.50	30.50	30.00	28.20	22.40	

Table 2: normal atmospheric condition for glass suspension-type insulator with guard ring.

RESISTANCE	5 e10	10 e10	20 e10	40 e10
η(%)	72.41	64.41	55.54	51.47

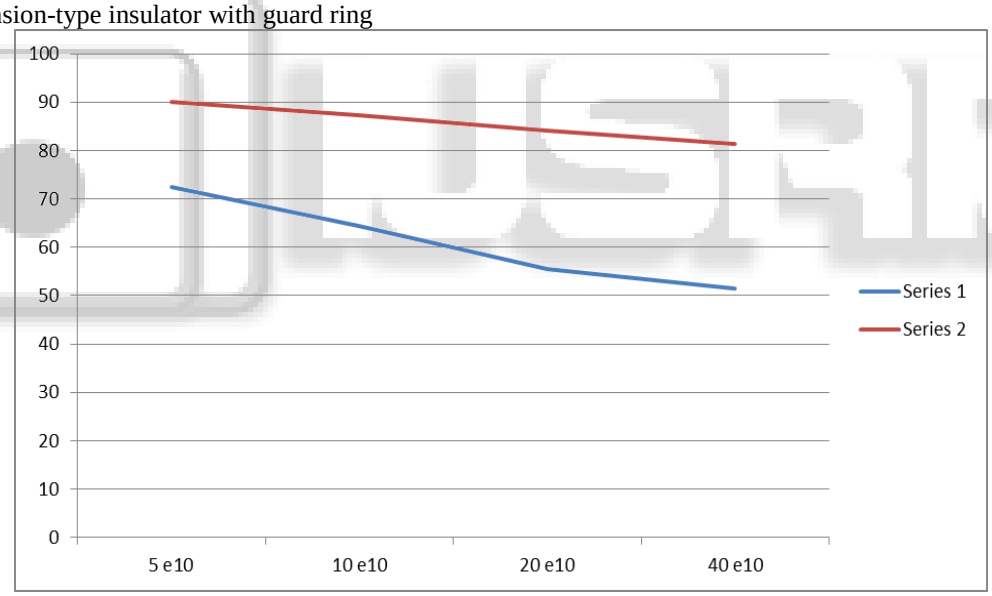
Table 3: polluted atmospheric condition for glass suspension-type insulator without guard ring

RESISTANCE	5 e10	10 e10	20 e10	40 e10
η(%)	90.11	87.25	84.18	81.26

Table 4: polluted atmospheric condition for glass suspension-type insulator with guard ring

A. GRAPH:

In graph X-axis shows resistance in ohm and Y-axis shows efficiency in percentage series-1 belongs to polluted atmospheric condition for glass suspensions type insulator without guard ring. And Series-2 belongs to polluted atmospheric condition for glass suspensions type insulator with guard ring.



VII. CONCLUSION

If there is a self-capacitance alone, then charging current would have been the same through all the discs and consequently voltage across each unit would have been the same. The voltage impressed on a string of suspension insulators does not distribute it self-presence of shunt capacitance. The disc nearest to the conductor has maximum voltage across it. Due to this reason puncture of insulator may result.by the use of guard ring voltage distribution can be improved. One of the main problem under which the distribution network is exposed in the environment pollution of its electrical Insulation. The particle Placed in the insulations are not dangerous in dry weather but the problem arises when the environmental wether is humid rains there is drew fog ,then layer can become conductor. This effect showed in this paper by parallel connection of resistance to each capacitor unit. As the value of resistance increases η(%)will be be decreases. uniformly across the individual discs due to the

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