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Comparative Analysis of Inductance and Capacitance in Single and Bundled Conductors in Different Configuration Using Excel-Based Modelling

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Abstract: This paper offers a comparative analysis of inductance and capacitance in both single and bundled conductors utilised in overhead transmission lines. The research centres on assessing the influence of conductor configuration on line parameters, which are essential for optimising power transmission efficiency. I used Microsoft Excel to make an analytical model that could figure out inductance and capacitance by changing important factors like the spacing, radius, and geometric mean radius (GMR) of the conductors. The idea of equivalent GMR was used to accurately show multi-conductor setups for bundled conductors. The analysis shows that bundled conductors have much lower inductance and much higher capacitance than single conductors. The enhanced performance is due to the larger effective radius and lower electric field intensity in bundled configurations. Graphical analysis shows even more how line parameters change based on spacing and conductor arrangement.

The results of this study show that bundled conductors are better for high-voltage transmission systems because they reduce losses and make the system work better overall. The suggested Excel-based method is a simple and useful way to look at transmission line parameters. It can also be used for more optimisation studies.
Keywords: Bundle conductor, Capacitance, GMD, GMR, Inductance, Transmission line.

I. INTRODUCTION

Electric power transmission is very important for getting electricity from power plants to homes and businesses in a safe and reliable way. The need for high-voltage transmission systems has grown as the demand for electricity has grown. In these kinds of systems, the electrical properties of transmission lines, especially inductance and capacitance, have a big effect on how well power can be transferred, how well voltage can be controlled, and how stable the whole system is.

Inductance in a transmission line is linked to the magnetic field that the current flowing through the conductors creates. Capacitance, on the other hand, is linked to the electric field that is created between the conductors and the ground. These parameters depend on a number of things, such as the distance between conductors, the radius of the conductors and how they are set up. of the conductors. This means that it is very important to accurately measure inductance and capacitance in order to design and run transmission lines well.

Traditionally, transmission lines used single conductors. However, as operating voltage levels have gone up, extra high voltage (EHV) and ultra-high voltage (UHV) systems now use bundled conductors. There are two or more sub-conductors per phase in bundled conductors. They are a short distance apart. This setup effectively makes the conductor system's equivalent radius bigger, which lowers inductance and raises capacitance. Also, bundled conductors help cut down on corona losses, radio interference, and noise that can be heard, which makes transmission more efficient.

This study conducts a comparative analysis of single and bundled conductors to examine their effects on transmission line inductance and capacitance. An analytical method employs Microsoft Excel to calculate line parameters by altering essential variables, including conductor spacing and geometric mean radius (GMR). For bundled conductor configurations, the idea of equivalent GMR is used to make sure that the modelling is correct.

The goal of this work is to look at how the inductance and capacitance change when different conductor arrangements are used. It also wants to show how bundled conductors are better than single conductors. The findings from this study yield valuable information for the design and enhancement of contemporary high-voltage transmission systems.

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II. THEORY

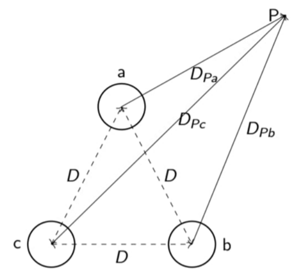
A. Inductance

Inductance is the property of a circuit that stops the value of a changing current from changing. The resistance of a circuit stops both steady and changing currents from flowing, but the inductance only stops changing currents. Inductance doesn't stop steady or direct current from flowing.

When it comes to transmission and distribution lines, the current that flow is either varying or alternating. This means that inductance, along with resistance, has an effect. People think of the resistance to the flow of changing current caused by inductance as a voltage drop.

In fact, magnetic lines of force surround the current-carrying conductor in concentric circles. In an AC system, the field around the conductor is not always the same; it changes and connects with the same conductor and other conductors. The line has inductance because of these flux linkages. Inductance is the number of flux linkages per unit of current. So, in order to find the inductance of a circuit, you need to find the flux linkages. Henry is the unit of inductance, and if you multiply it by 2 x π x f, you get ohm.

- Inductance of Three phase line conductor with symmetrical spacing



$$L = 2 \times 10^{-7} \left(\ln \frac{D}{r'}\right) \text{ H/m} \quad (1)$$

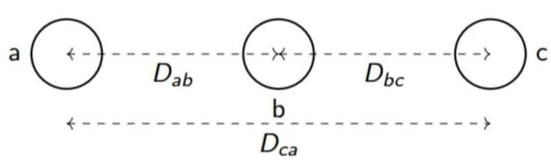
Where $r' = re^{-\frac{1}{4}} = r \times 0.7788$

The inductances of phases b and c will be the same as a because they are symmetrical.

La = Lb = Lc

Because Ib + Ic = -Ia, λa does not have a term for mutual flux linkage. The inductances of the phases are the same. However, it is hard to put transmission lines with the same amount of space between them in real life.

- Inductance of three phase line conductor with unsymmetrical spacing



$$L_a = 2 \times 10^{-7} \ln \frac{GMD}{r'} \text{ H/m} \quad (2)$$

Where GMD is the geometric mean distance.

$GMD = \sqrt[3]{D_a D_b D_c}$

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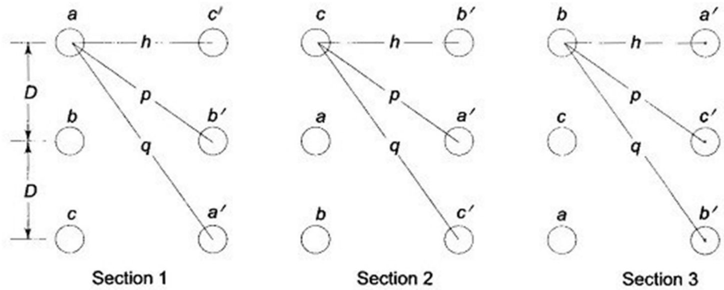
- Inductance of double circuit transmission line with vertical spacing



$$\boldsymbol{L = 2 \times 10^{-7}\ \ln\frac{GMD}{GMR}\ \mathrm{H/m}} \quad \textbf{(3)}$$

Where, GMD is the geometric mean distance in m and GMR is the geometric mean radius in m.

$$GMD = \sqrt[3]{D_{ab}D_{bc}D_{ca}}$$

Were

$$D_{ab} = \sqrt[4]{D_{ab}D_{ab'}D_{a'b}D_{a'b'}}$$
$$D_{bc} = \sqrt[4]{D_{bc}D_{bc'}D_{b'c}D_{b'c'}}$$
$$D_{ca} = \sqrt[4]{D_{ca}D_{ca'}D_{c'a}D_{c'a'}}$$

And

$$GMR = \sqrt[3]{GMR_a GMR_b GMR_c}$$

Where

$$GMR_a = \sqrt[2]{r'^{D_{aa'}}}$$
$$GMR_b = \sqrt[2]{r'}D_{bb'}$$
$$GMR_c = \sqrt[2]{r'}D_{cc'}$$

B. Capacitance

When two conductors are separated by an insulating medium, they form a condenser or a capacitor. In an overhead line, the two conductors act as the plates of a capacitor, and the air between them serves as the dielectric medium. Therefore, we can assume that an overhead line has capacitance between the conductors along its entire length. This capacitance is evenly distributed over the total length of the line and can be viewed as a series of uniform condensers connected between the conductors.

An alternating EMF, when applied across a transmission line, takes a leading current, regardless of the load on the system. It is known as the charging current, which leads the applied voltage by 90 degrees.

The cause behind the charging current in the system is the capacitance of the system. It is independent of the load in any manner. The magnitude of the charging current depends upon the following factors: transmission voltage, capacitance of the line, and ac frequency.

$$\boldsymbol{C = \frac{2\pi\epsilon_0}{\ln\frac{GMD}{r}}\ \mathrm{F/m}}$$

The higher the value of capacitance in an overhead power line, the higher the amount of charging current drawn in it. This helps to cancel or offset the lagging component of the load current. The resultant current is therefore low. The unit of capacitance is Farad, and by multiplying it with 2 x π x f gives ohm.

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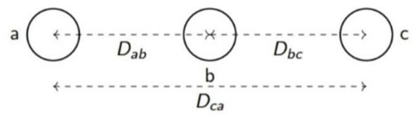
- Capacitance of the three-phase transposed line



In general,

$$C = \frac{2\pi\epsilon_0}{\ln\frac{GMD}{GMR}} \text{ F/m} \quad (4)$$

Where,

$$GMD = \sqrt[3]{D_{ab}D_{bc}D_{ca}}$$

Here the calculation for GMD is same as inductance.

For bundle conductors there is change in GMR calculations

For a single conductor per phase

$$GMR = r$$

For 2- conductor bundle, $GMR = \sqrt{r' \times d}$

For 3- conductor bundle, $GMR = \sqrt{r \times d \times d}$

For 4- conductor bundle, $GMR = \sqrt{r \times d \times d \times d}$

III. METHODOLOGY

This paper employs an analytical method in assessing the inductance and capacitance of transmission lines depending on various conductor arrangements. The assessment is done using Microsoft Excel, where computation and plotting of the results are performed.

First, the basic formulas for inductance and capacitance of transmission lines are incorporated into Excel. Data inputs such as radius of conductors, spacing of conductors, and permittivity of medium are provided. Geometric Mean Radius (GMR) is determined to factor in the internal flux linkage of the conductors. In case of bundled conductors, equivalent GMR is considered with reference to the number of sub-conductors and spacing.

To analyse the effect of conductor arrangement, multiple configurations are considered, including single conductor, bundled conductor, vertical arrangement, hexagonal arrangement, and double circuit transmission lines.

For In case of unsymmetric conductors like vertical and double circuits, the equivalent spacing or geometric mean distance (GMD) is determined using formulas to facilitate calculations.

Parametric analysis is conducted through changing the spacing and conductor configuration to study their effects on inductance and capacitance. Calculated results are presented in tabular form along with graphs to represent changes in transmission line parameters due to spacing and conductor configuration.

Eventually, the outcomes are compared among various configurations to find out the optimal configuration in terms of minimum inductance and maximum capacitance. This method can be used to systematically analyze transmission line parameters and compare single and bundled conductors under various configurations.

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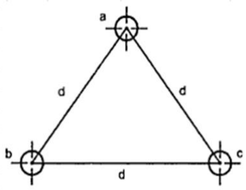
IV. SAMPLE CALCULATION

Calculation for single circuit single conductor and bundle conductor

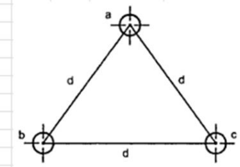
calculation for three phase line (Equilitral spacing)



Distance between a & b conductors (D_{ab}) =	2			m
Distance between b & c conductors (D_{bc}) =	2			m
Distance between c & a conductors (D_{ca}) =	2			m
Select the conductors from list=	PANTHER			
Voltage level=	33			kv
Radius of conductor=	0.0105			m
Require Average ground clearance=	9			m
Total GMD =	[Dab x Dbc x Dca]$^{1/2}$	=	2	m
Effective radius (GMR or r') =	0.7788x0.0105	=	0.00818	m
Inductance =	2x10^-7xln(GMD/r')			
=	2x10^-7xln(2/0.0081774)			
=	0.001099906			H/km
Inductive reactance (X_l)=	2xπxfL			
=	0.345370371			Ω/km
Capacitance=	2xπxε./ln(GMD/r)			
=	2xπxε./ln(2/0.0105)			
=	1.05974E-08			F/km
Capacitive reactance (X_c)=	1/(2xπxfC)			
=	300518.4612			Ω/km

1. Single conductor

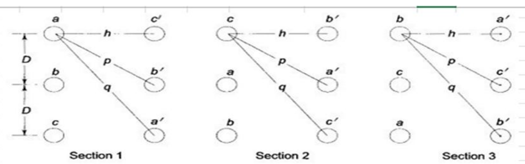
Calculation for three phase line (Equilitral spacing)



Distance between a & b conductors (D_{ab}) =	2			m
Distance between b & c conductors (D_{bc}) =	2			m
Distance between c & a conductors (D_{ca}) =	2			m
Select the conductors from list=	PANTHER			
Voltage level=	400			kv
No of conductors in bundle(n)=	3			
Sub conductor spacing($D_{bund.}$)=	0.4			m
Radius of conductor(r)=	0.0105			m
Require Average ground clearance=	22			m
Total GMD =	[Dab x Dbc x Dca]$^{1/2}$	=	2	m
Effective radius (r') =	0.7788x0.0105	=	0.0082	m
Effective GMR of bundle(for L)=	r'x(Dbund.^(n-1)))^(1/n	=	0.10937	m
GMR of bundle (for C)=	(rx(Dbund.^(n-1)))^(1/n)	=	0.11888	m
Inductance =	2x10^-7xln(GMD/Eff. GMR)			
=	2x10^-7xln(2/0.1093734072149)			
=	0.00056456			H/km
Inductive reactance (X_l)=	2xπxfL			
=	0.177271903			Ω/km
Capacitance=	2xπxε./ln(GMD/GMR)			
=	2xπxε./ln(2/0.118878439055263)			
=	1.97078E-08			F/km
Capacitive reactance (X_c)=	1/(2xπxfC)			
=	161596.232			Ω/km

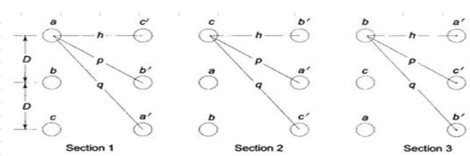
2. Bundle conductor

Calculation for Double circuit single and bundle conductor



Horizonrtal distance between two (h)=	4			m
vertical distance between two phases (D)=	2			m
Select the conductors from list=	PANTHER			
Voltage level=	400			kv
Radius of conductor=	0.0105			m
Require Average ground clearance h_G=	22			m
Effective radious (r') =	0.7788x0.0105	=	0.00818	m
Distance between ($D_{aa'}$)=	[(2D)^2 + (h)^2]$^{1/2}$	=	5.65685	m
Distance between ($D_{bb'}$)=	[h]	=	4	m
Distance between ($D_{cc'}$)=	[(2D)^2 + (h)^2]$^{1/2}$	=	5.65685	m
GMR calculation for inductance:				
a phase self GMR (D_{sa})=	[$D_{aa'}$ x r']$^{1/2}$	=	0.21508	m
b phase self GMR (D_{sa})=	[$D_{bb'}$ x r']$^{1/2}$	=	0.18086	m
c phase self GMR (D_{Sc})=	[$D_{cc'}$ x r']$^{1/2}$	=	0.21508	m
Equivalent system GMR_L=	[D_{sa} x D_{Sb} x D_{Sc}]$^{1/3}$	=	0.20301	m
GMR calculation for Capacitance:				
a phase self GMR (D_{sa_c})=	[$D_{aa'}$ x r]$^{1/2}$	=	0.24371	m
b phase self GMR (D_{Sb_c})=	[$D_{bb'}$ x r]$^{1/2}$	=	0.20494	m
c phase self GMR (D_{Sc_c})=	[$D_{cc'}$ x r]$^{1/2}$	=	0.24371	m
Equivalent system GMR_c =	[D_{sa_c} x D_{Sb_c} x D_{Sc_c}]$^{1/3}$	=	0.23004	m
GMD calculation:				
GMD bet^n a & b Ph (D_{ab})=	[D_{ab} x $D_{ab'}$ x $D_{a'b}$ x $D_{a'b'}$]$^{1/4}$	=	2.9907	m
GMD bet^n b & c Ph (D_{bc})=	[D_{bc} x $D_{bc'}$ x $D_{b'c}$ x $D_{b'c'}$]$^{1/4}$	=	2.9907	m
GMD bet^n c & a Ph (D_{ca})=	[D_{ca} x $D_{ca'}$ x $D_{c'a}$ x $D_{c'a'}$]$^{1/4}$	=	4	m
Equivalent system GMD_{Eq} =	[D_{ab} x D_{bc} x D_{ca}]$^{1/3}$	=	3.2951	m
Inductance=	2x10^-7xln(GMDeq/GMR_L)			
=	2x10^-7xln(3.29509794488413/0.203006190973678)			
=	0.000557391			H/km
Inductive reactance (X_l)=	2xπxfL			
=	0.175020755			Ω/km
Capacitance=	2xπxε./ln(GMDeq/GMR_c)			
=	2xπxε./ln(3.29509794488413/0.230036266913686)			
=	2.08987E-08			F/km
Capacitive reactance (X_c)=	1/(2xπxfC)			
=	152388.2718			Ω/km

3 Single conductor



Horizonrtal distance between two (h)=	4			m
vertical distance between two phases (D)=	2			m
Select the conductors from list=	PANTHER			
Voltage level=	400			kv
No of conductors in bundle(n)=	4			
Sub conductor spacing($D_{bund.}$)=	0.4			m
Radius of conductor=	0.0105			m
Require Average ground clearance h_G=	22			m
Effective radious (r') =	0.7788x0.0105	=	0.0082	m
Effective GMR of bundle(for L)=	r'x(Dbund.^(n-1)))^(1/n	=	0.151251	m
GMR of bundle (for C)=	(rx(Dbund.^(n-1)))^(1/n	=	0.161006	m
Distance between ($D_{aa'}$)=	[(2D)^2 + (h)^2]$^{1/2}$	=	5.6569	m
Distance between ($D_{bb'}$)=	[h]	=	4	m
Distance between ($D_{cc'}$)=	[(2D)^2 + (h)^2]$^{1/2}$	=	5.6569	m
GMR calculation for inductance:				
a phase self GMR (D_{sa})=	[$D_{aa'}$ x Eff. GMR]$^{1/2}$	=	0.925	m
b phase self GMR (D_{sa})=	[$D_{bb'}$ x Eff. GMR]$^{1/2}$	=	0.7778	m
c phase self GMR (D_{Sc})=	[$D_{cc'}$ x Eff. GMR]$^{1/2}$	=	0.925	m
Equivalent system GMR_L=	[D_{sa} x D_{Sb} x D_{Sc}]$^{1/3}$	=	0.8731	m
GMR calculation for Capacitance:				
a phase self GMR (D_{sa_c})=	[$D_{aa'}$ x GMR]$^{1/2}$	=	0.9544	m
b phase self GMR (D_{Sb_c})=	[$D_{bb'}$ x GMR]$^{1/2}$	=	0.8025	m
c phase self GMR (D_{Sc_c})=	[$D_{cc'}$ x GMR]$^{1/2}$	=	0.9544	m
Equivalent system GMR_c =	[D_{sa_c} x D_{Sb_c} x D_{Sc_c}]$^{1/3}$	=	0.9008	m
GMD calculation:				
GMD bet^n a & b Ph (D_{ab})=	[D_{ab} x $D_{ab'}$ x $D_{a'b}$ x $D_{a'b'}$]$^{1/4}$	=	2.9907	m
GMD bet^n b & c Ph (D_{bc})=	[D_{bc} x $D_{bc'}$ x $D_{b'c}$ x $D_{b'c'}$]$^{1/4}$	=	2.9907	m
GMD bet^n c & a Ph (D_{ca})=	[D_{ca} x $D_{ca'}$ x $D_{c'a}$ x $D_{c'a'}$]$^{1/4}$	=	4	m
Equivalent system GMD_{Eq} =	[D_{ab} x D_{bc} x D_{ca}]$^{1/3}$	=	3.2951	m
Inductance=	2x10^-7xln(GMDeq/GMR_L)			
=	2x10^-7xln(3.29509794488413/0.873074016889589)			
=	0.000265634			H/km
Inductive reactance (X_l)=	2xπxfL			
=	0.083409128			Ω/km
Capacitance=	2xπxε./ln(GMDeq/GMR_c)			
=	2xπxε./ln(3.29509794488413/0.900788474400647)			
=	4.28949E-08			F/km
Capacitive reactance (X_c)=	1/(2xπxfC)			
=	74244.51782			Ω/km

4. Bundle conductor

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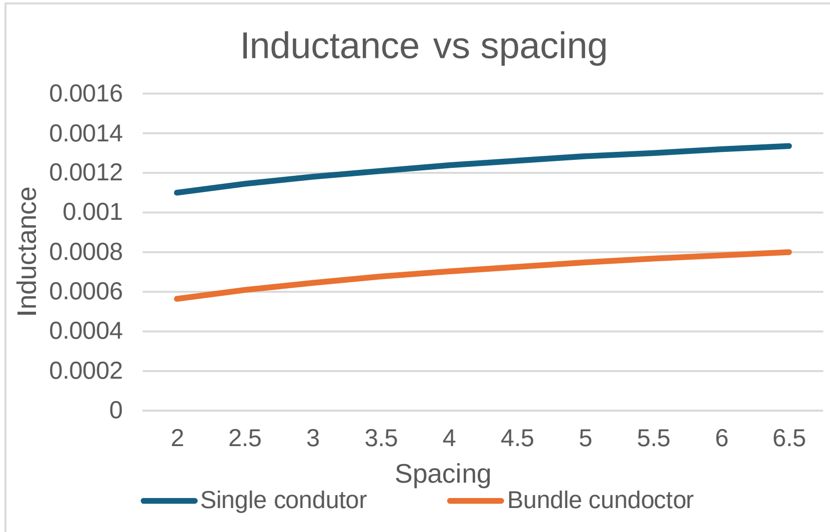
V. RESULTS

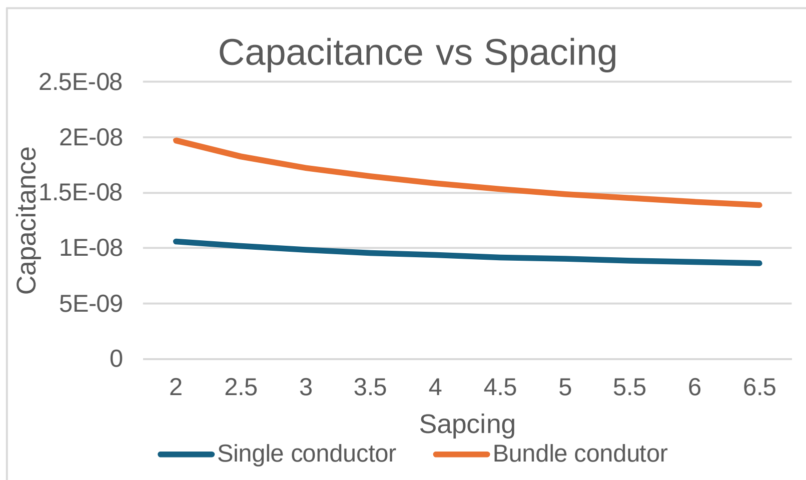
1) Spacing vs Inductance (Single ckt)

Spacing in m	**Single conductor**	**Bundle conductor**
	L in H/km	L in H/km
2	0.001099906	0.00056456
2.5	0.001144534	0.000609189
3	0.001180999	0.000645653
3.5	0.001211829	0.000676483
4	0.001238535	0.00070319
4.5	0.001262092	0.000726746
5	0.001283164	0.000747818
5.5	0.001302226	0.00076688
6	0.001319628	0.000784283
6.5	0.001335637	0.000800291



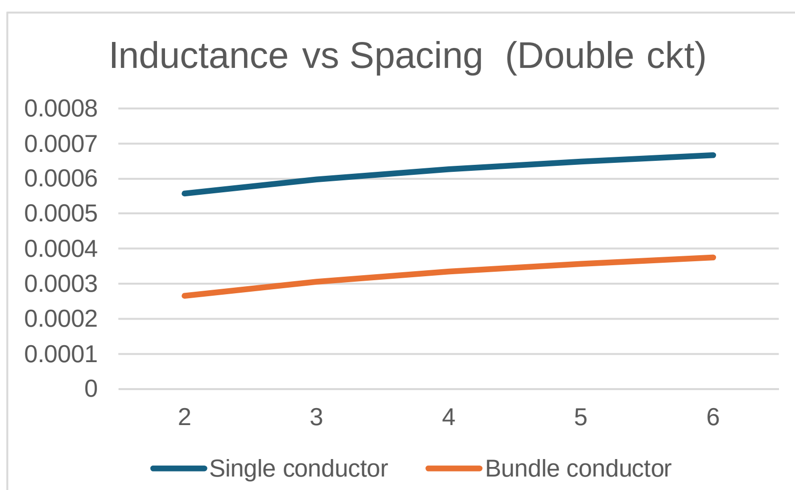
2) Spacing vs Capacitance (single ckt)

Vertical spacing	Single conductor	Bundle conductor
	C in F/km	C in F/km
2	2.08987E-08	4.28949E-08
3	1.94197E-08	3.70961E-08
4	1.84912E-08	3.38494E-08
5	1.783E-08	3.16976E-08
6	1.73238E-08	3.01324E-08



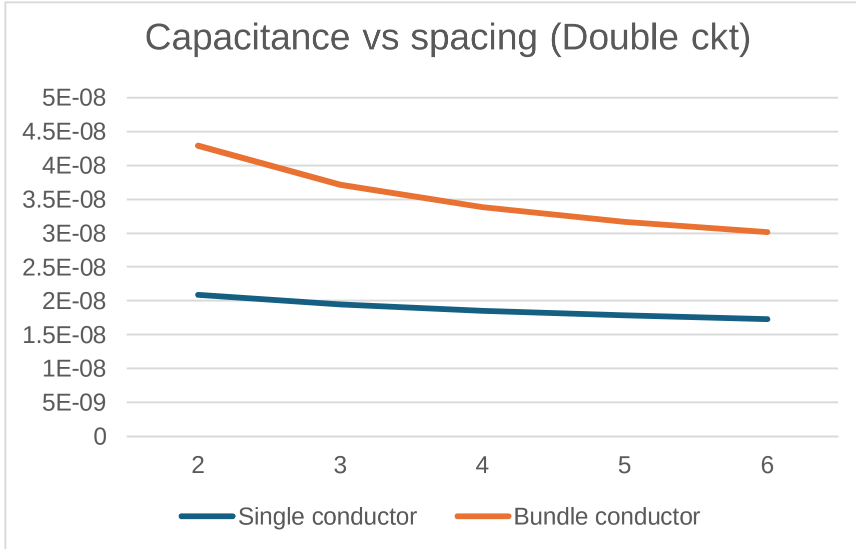
3) Spacing vs inductance (Double ckt)

Vertical spacing	Single conductor	Bundle conductor
	L in F/km	L in H/km
2	0.000557391	0.000265634
3	0.000597937	0.000306181
4	0.000626706	0.000334949
5	0.00064902	0.000357263
6	0.000667252	0.000375495



4) Spacing vs Capacitance (Double ckt)

Vertical spacing	Single conductor	Bundle conductor
	C in F/km	C in F/km
2	2.08987E-08	4.28949E-08
3	1.94197E-08	3.70961E-08
4	1.84912E-08	3.38494E-08
5	1.783E-08	3.16976E-08
6	1.73238E-08	3.01324E-08



VI. DISCUSSION

The results obtained from the graphical representation show how the spacing between conductors and their arrangement affect the inductance and capacitance of the transmission lines. From the graph of inductance against spacing, it can be noted that the inductance will always rise with rising spacing between the conductors in any case. This happens because the magnetic linkage becomes high as the distance between the conductors becomes large. In the case of single conductors and bundled conductors, it can be seen that the inductance of the bundled conductors is lower than that of the single conductors when both have similar spacings. The reason behind this is that the bundled conductors have a higher GMR value compared to the single conductors, which results in lower inductive reactance. Moreover, the inductance decreases as the sub-conductors in the bundle increase. As can be seen from the graph on the dependence of the capacitance on the spacing, it can be stated that the capacitance decreases with an increase in spacing in all the cases studied. However, in terms of bundled conductors, it can be observed that they have greater capacitance than single conductors since bundling makes the radius of the conductor larger and thus improves the electric field interaction and increases capacitance. Regarding single circuit and double circuit transmission lines, it can be observed that the same pattern is exhibited in both types of circuits. Double circuit transmission lines tend to have less inductance compared to single circuit transmission lines due to the effect of mutual coupling. The existence of additional conductors affects the magnetic field interaction in such a way that the inductance reduces. It is also found that capacitance in double circuit transmission lines tends to be higher than in single circuit transmission lines. Furthermore, the graph illustrating comparison at constant spacing serves to demonstrate that both the bundled conductor system and the double circuit system outperform the single conductor and single circuit system in terms of electric effectiveness. Lower inductance and higher capacitance serve to make the two configurations more appropriate for high voltage transmission due to their ability to regulate voltage and minimize transmission losses. Overall, the results indicate that conductor configuration plays a crucial role in determining transmission line parameters. The use of bundled conductors and double circuit arrangements significantly enhances system performance, making them preferable choices in modern power transmission systems

VII. PERCENTAGE ANALYSIS

To evaluate the improvement in transmission line performance, a percentage analysis is carried out for inductance and capacitance by comparing different conductor configurations.

1) Percentage reduction in inductance (single circuit).

The percentage reduction in inductance is calculated using

$$\%\,Reduction\ in\ inductance = \frac{L_{single} - L_{bundle}}{L_{single}} \times 100$$

$$\%\, Reduction\ in\ inductance = \frac{0.001238535 - 0.00070319}{0.001238535} \times 100 = 43\%$$

Here, configuration is single circuit and D = 4m and Bundle spacing D_{bundle} = 0.4m
L_{single} inductance of single conductor
$L_{modified}$ inductance of bundle conductor

2) Percentage increase in Capacitance (single circuit).

The percentage increase in capacitance is calculated using

$$\%\, Incease\ in\ Capacitance = \frac{C_{bundle} - C_{single}}{C_{single}} \times 100$$

$$\%\, Increase\ in\ Capacitance = \frac{(1.58226E-08) - (9.36133E-09)}{(9.36133E-09)} \times 100 = 69.02\%$$

Here, configuration is single circuit and D = 4m and Bundle spacing D_{bundle} = 0.4m
C_{single} Capacitance of single conductor
C_{bundle} Capacitance of bundle conductor

3) Percentage reduction in inductance (Double circuit).

The percentage reduction in inductance is calculated using

$$\%\, Reduction\ in\ inductance = \frac{L_{single} - L_{double}}{L_{single}} \times 100$$

$$\%\, Reduction\ in\ inductance = \frac{0.000626706 - 0.000334949}{0.00062670} \times 100 = 46.55\%$$

Here, configuration of single circuit is D = 4m and double circuit is D=4 and h (horizon. dist.) =8m $L_{single\ circuit}$ inductance of single circuit.
L_{double} inductance of double circuit.

4) Percentage increase in Capacitance (Double circuit).

The percentage increase in capacitance is calculated using

$$\%\, Incease\ in\ Capacitance = \frac{C_{double} - C_{single}}{C_{single}} \times 100$$

$$\%\, Increase\ in\ Capacitance = \frac{(3.38494E-08) - (1.84912E-08)}{(1.84912E-08)} \times 100 = 83.05\%$$

Here, configuration of single circuit is D = 4m and double circuit is D=4 and h (horizon. dist.) =8m C_{single} Capacitance of single circuit
C_{double} Capacitance of double circuit

- For instance, in relation to the inductance values for the single circuit with the bundled conductors, there has been a decline from 0.001238535 henry to 0.00070319 henry, representing approximately 43 percent. This can be attributed to an increase in effective conductor radius due to bundling that minimizes magnetic flux linkage. On the other hand, in relation to the inductance values for the double circuit, the inductance declines from 0.000626706 henry to 0.000334949 henry, which represents a decline of approximately 46.55 percent. The latter has resulted from a mutual coupling effect between the conductors of the two circuits leading to the cancellation of magnetic fields.
- The effect on capacitance is as follows; the first value in relation to the bundled conductor single circuit is 9.36133×10^{-9} farad, but through bundling, the capacitance has been increased to 1.58226×10^{-8} farad, translating to an increase of approximately 69.02 percent. This has been made possible due to an increase in the effective surface area of the conductor. On the other hand, in the double circuit, the capacitance rises from 1.84912×10^{-8} farad to 3.38494×10^{-8} farad, which translates to an increase of 83.05 percent.

- In general, there is considerable improvement in transmission lines with regard to their ability to lower the inductance and raise the capacitance. It is clear, however, that the double circuit configuration performs better, as it lowers the inductance and raises the capacitance even more. This proves that there is much electromagnetic interference between the circuits adjacent to each other.

VIII. CONCLUSION

For the purpose of this experiment, a comparison is made of the inductance and capacitance of transmission lines for different conductor configurations, namely the single conductor, bundled conductor, and double circuit. The calculation is done by the Excel method, where the effect of spacing, geometric mean radius, and geometric mean distance is considered.

It is evident from the results that there is a considerable impact of conductor configuration on transmission line characteristics. As it can be seen from the results, an increase in spacing leads to higher values of inductance, while an increase in spacing reduces capacitance. When comparing the values of a single conductor with a bundled conductor, there is a marked decrease in inductance and increase in capacitance.

Moreover, a double circuit arrangement shows improved characteristics as compared to a single circuit and bundled conductor arrangement. The value of inductance in a double circuit decreases from 0.000626706 Henry to 0.000334949 Henry showing a reduction of about 46.55%, while that of capacitance goes from 1.84912×10^{-8} farad to 3.38494×10^{-8} farad, signifying an increase of 83.05%. This is mainly due to the electromagnetic coupling effects between conductors of adjacent circuits, reducing the magnetic flux linkages and increasing the effect of electric field.

The percentage calculations reveal that inductive effects of bundled conductors decrease to about 43% and capacitive effects go up by about 69.02%, whereas in the case of a double circuit configuration, the reduction in inductance is more than the former (46.55%) and an increase in capacitance is significantly more (83.05%).

On the whole, from the analysis and calculations, it is apparent that an efficient conductor configuration like double circuit is highly advantageous in order to improve the efficiency of power transmission, voltage regulation and other power transmission properties. Furthermore, the use of excel modelling for analysing the values of these parameters is very convenient and useful.

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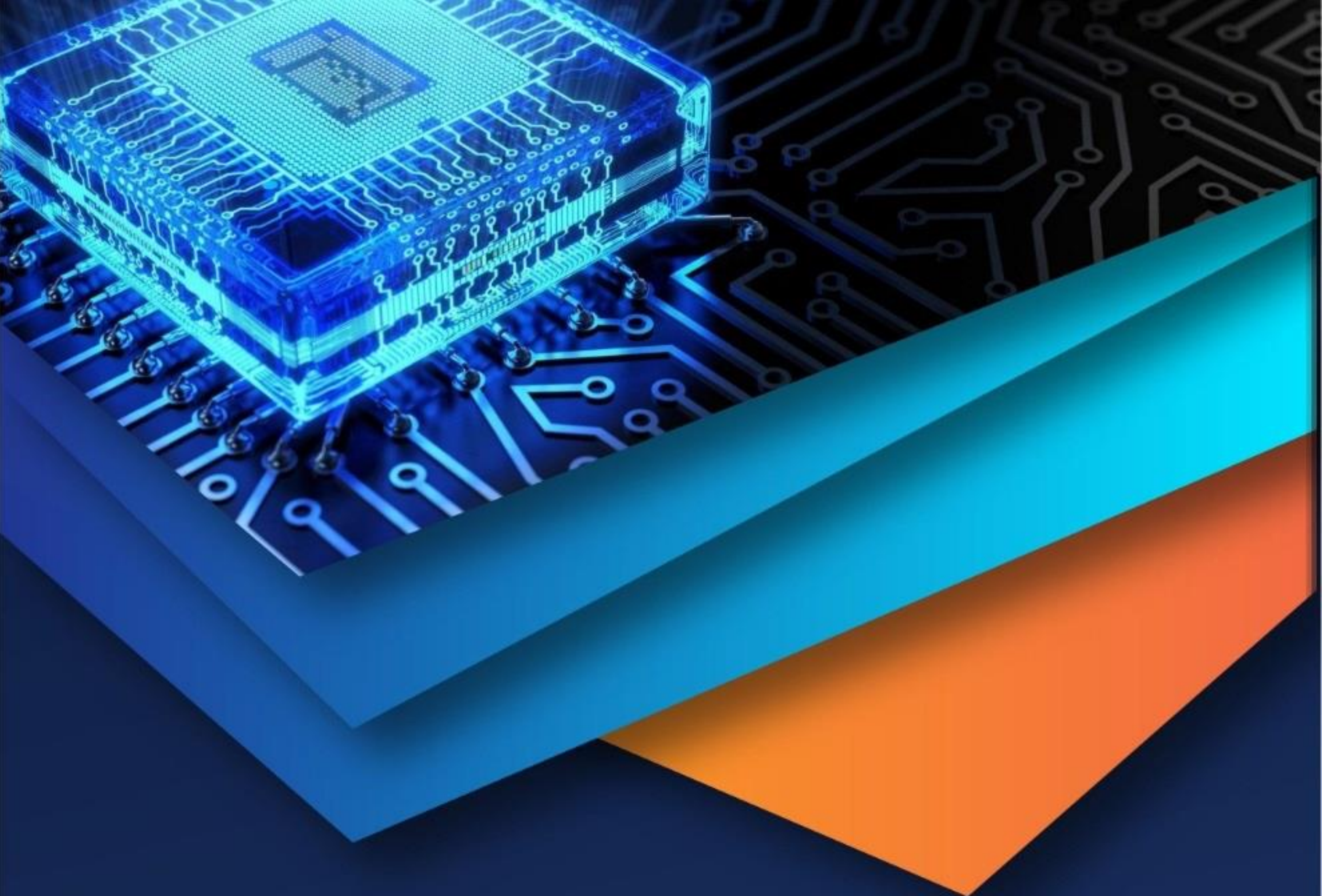

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