Comparison Between High Order Compact and Central Difference Methods For Evaluating Electromagnetic Fields From Power Transmission Lines

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Abstract

This paper compares a finite difference method-based computational scheme for evaluating electromagnetic field problems in power transmission lines in cases of on surface and in Ground. The scheme uses Maxwell's partial differential equations to represent electric, magnetic field components, and approximate boundary conditions. The High Order Compact Method (HOC) is applied to estimate the electric field Ez in ground and compares it with the standard central difference scheme. The HOC produces more accurate results than the traditional central approximation at 99.7% for the electric field Ez. It also calculates both of Electric and magnetic fields intensities to evaluate the effect of Electric and magnetic intensities in ground and on surface respect to distance.

Keywords *- Power Transmission Line- Central Difference Scheme - High Order Compact, Boundary conditions, Electric intensity, magnetic intensity*

1. Introduction

In recent studies, scientific systems have performed significant research that investigating the existing electromagnetic field issues through a high order compact method. The methods open up a possibility to reduce the computational error and get an accurate representation of the electromagnetic fields nearby electrical transmission lines. Available sources confirm that the high order compact method is an essential approach to the assessment of electromagnetic field issues due to the provision of results with high accuracy and the reduced computational requirements, to enhance the resolution at high wavenumbers. [1] [2] .Finite Difference Method has been having been applied to investigate electromagnetic fields within systems ranging from power transformers to generators, the work has been mainly focused on small-scale systems; as power transmission lines above the earth over long distances. As introducing into the High Order Compact Difference Method, a computational technique that supports the assessment of electromagnetic fields made by currents flowing through the power transmission line, mainly single-phase-to-earth error conditions, the process was used to develop advanced protocols for numerically Based on Carson's formulation assumptions, the electric field components ***Ex*** and ***Ey*** due to the ground current are neglected, and the only significant component is ***EZ*** by [*Elhirbawy, M. A., et al*] analyzing the electromagnetic field's influence on power transmission lines. Also in 2002 [*M. Elhirbawy ,et al*.] uses Finite Difference Method (FDM) for calculating electromagnetic fields in power transmission lines. FDM is simple to formulate and extends to two or three-dimensional problems with less computational work. The study calculates magnetic and electric fields using various parameters like step size, conductor height, resistivity, and fault current. The study concludes that FDM is a valuable numerical technique for solving Maxwell's partial differential equations, offering a comprehensive approach to electromagnetic field problems. In 2003[*Al*

Dhalaan, S. M. et al] was Showed there was a small change in the electromagnetic field magnitudes for frequencies of 50 and 60 Hz. In conclusion, the paper provides insights into magnetic coupling between power transmission lines and metallic structures like railways at surface level [4] It offers a comprehensive analysis of electromagnetic field distribution near high voltage low-frequency lines, serving as an alternative tool for such calculations.

The High Order Compact Difference Method shows great promise for the assessment of magnetic coupling at the supply frequency between transmission lines and metallic structures buried in the ground, such as pipelines. Various literature reviews and discussions within the power industry have highlighted the urgent requirement for critical means of addressing many demanding electromagnetic field problems that arise from transmission lines.

2. Background

2.1 High Order Compact Methods: Advantages of using the high-order compact method for power transmission line: **Space-Efficiency**: Compact transmission lines designed using this method take less lateral space according to modern materials and altered tower geometries reducing visual impact and space requirements.

Cost-Effectiveness: Construction of compact overhead lines is often cheaper than traditional lines, especial in the 20-220 kV voltage range, making it an economical attractive solution. [2]

Reliability and Safety: The design of compact lines improve reliability, safety, and the transiting ability of power lines, ensuring improved performance and reduced risks associated with electromagnetic fields.

Increased Voltage Gradients: By reducing phase-to-phase and phase-to-structure distances, the high-order compact method increases voltage gradients on conductors, that will lead to reduced flashover voltage thresholds and improved performance [2].

Environmental Performance: The reduction of electromagnetic fields in outer space through compact line design can lead to improved environment performance of the power line, making it a more sustainable option.

A class of high-order compact (HOC) exponential finite difference (FD) algorithms to solve many problems such as steady-state convection-diffusion problems in one and two dimensions. The recently suggested HOC exponential FD schemes are appropriate for convection-dominated environments and produce highly accurate approximation solutions The tridiagonal Thomas algorithm can be used to solve the diagonally dominant tri-diagonal system of equations that are produced by the O(h4) compact exponential FD schemes designed for one-dimensional (1D) problems. The line iterative approach with alternating direction implicit (ADI) procedure allows us to deal with diagonally dominant tridiagonal matrix equations, which can be solved by application of the one-dimensional tridiagonal Thomas algorithm. $O(h^4 + k^4)$ compact exponential FD schemes are formulated on the nine-point 2D stencil for the two-dimensional (2D) problems.[7]

When simulating a variety of physical processes, typical low-order algorithms can have restrictions that can be overcome by using high-order numerical approaches, such as electromagnetics, High-order approaches can yield more accurate results on finer computational grids than low-order techniques because of their improved capacity to represent waves at high frequencies and/or with limited grid support. This leads to a reduction in the overall computing effort. But most of the early attempts that employing high-order methods, simple domains and Cartesian grids have been used for a number of reasons, including the lack of defined curvilinear-grid techniques for various types of high-order approaches and the limited flexibility of spectral methods[8]

2.2 Power Transmission Line Models

Electric fields, measured in kV/m, are invisible forces between positive and negative charges in various locations like home wiring and power lines. Their strength is directly proportional to system voltage, and electric take safe.[5]

Electricity is produced, transported, and disseminated through power lines, cables, and electrical equipment, involving magnetic and electric fields. Electrical systems operate at 50 Hertz (Hz) and produce extremely low frequency (ELF) EMF. Voltage determines electric fields, and surrounding a transmission line, the electric field remains relatively constant. Higher operating voltage leads to higher electric fields around the conductor, partially at ground level. The ICNIRP basic restriction and reference levels indicate that the electric field around the head is 0.02 v/m, while all tissues of the head and body are 0.4 v/m [6] .

The ground's surface connects the two regions, which are above and below ground. An effective boundary condition has been applied for a small diameter in ground. These boundaries are the nine HOC points around the surface as the region Power Transmission Line is assumed to calculate have been made for the electric and magnetic fields on surface to be applied as a boundary condition.[4]

2. 3 Boundary Points and Conditions

Boundary conditions for boundaries at a long distance, utilizing the Carson formulation which is determined from the conductors of both regions. The total magnetic field (the sum of the conductor and image contributions) must match the magnetic field below ground at the surface in order to satisfy the boundary criteria of continuity in both the horizontal and vertical components of magnetic fields at the ground surface.[3]

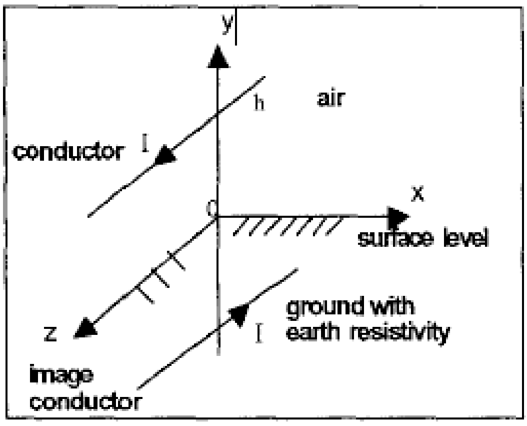

Fig. 1: Carson formulation[1]

2.3.1Magnetic Field on the Surface

Transmission and distribution lines for electricity have been in service for roughly the electric exposed to magnetic fields from power wires and other sources may be experiencing health effects.[9] So it has been implemented, is to calculate the image components Hxi and Hyi[5].

2.3.2Electric Field in the Ground

Using the Maxwell equations [5]:

curl(E)= - $j\omega\mu_0\ H$

curl(H)= - $j\omega\varepsilon_0\ E$

Electric filed related to current density

i = E/ρ_e
curl H= E/ρ_e+ $j\omega\varepsilon_0 E$
when $\frac{1}{\rho_e} \gg \omega\varepsilon_0$
then curl H= E/ρ_e
crul (curl(E))=(0,0,$-\frac{\partial^2 z}{\partial x^2}+\frac{\partial^2 z}{\partial y^2}$) , so the equation is reduced to an equation for Z-direction only[5]

3. Simulation Setup:

3.1 Mathematical modeling

Calculate Exact solution for Electric field in ground E_z for equation [5]:

$$E_z = -\int_0^{\infty} F(u)\cos(ux)e^{y\sqrt{u^2+j\alpha}}\,du$$

$F(u) = \frac{\mu_0}{\pi}\frac{j\omega I e^{-hu}}{\sqrt{u^2+j\alpha+u}}$ and $\alpha = \mu_0\omega/\rho_e$

The Numerical Solutions:

1.High – Order compact finite difference method : With uniform grids that is Δx= Δy= δx=1
High –Order compact finite difference method (nine points)
20u(i,j)= 4(u(i-1,j)+ u(i+1,j)+ u(i,j-1)+ u(i,j+1))+ u(i-1,j-1)+u(i+1,j+1)+ u(i-1,j+1)+ u(i+1,j-1)
let Δx =1/4
i=1,2,3 and j=1,2,3

2. Central finite Difference Method
2u(i,j)=u(i+1,j)+u(i-1,j)+u(i,j+1)+u(i,j-1)

3.2 Results and Discussion

3.2.1 Calculate Exact solution for Electric field in ground E_z [5]

$$E_z = -\int_0^{\infty} F(u)\cos(ux)e^{y\sqrt{u^2+j\alpha}}\,du$$

$F(u) = \frac{\mu_0}{\pi}\frac{j\omega I e^{-hu}}{\sqrt{u^2+j\alpha+u}}$ and $\alpha = \mu_0\omega/\rho_e$

Ez = -0.48254386 + -2.50786568i

Numerical Solutions:

3.2.1.1 Central finite Difference Method as :
2u(i,j)=u(i+1,j)+u(i-1,j)+u(i,j+1)+u(i,j-1)
let Δx =1/4
i=1,2,3 and j=1,2,3

Table 1: Central Difference Solution :

0.239862355733735+ 1.336607024315101i	0.724336389467080 + 3.734161884676705i	0.244036023094470 + 1.117447997990019i
0.721021445526651 + 3.920419080941371i	1.446766837426400 + 7.560710732349492i	0.726029646888425 + 3.622095461394656i

0.238499001183749 + 1.413264607101781i	0.722146192970645 + 3.844745037686257i	0.242115822341941 + 1.188908402617896i

absolute_error1: 3.911756781134865

3.2.1.2 High –Order compact finite difference method (nine points)

20u(i,j)= 4(u(i-1,j)+ u(i+1,j)+ u(i,j-1)+ u(i,j+1))+ u(i-1,j-1)+u(i+1,j+1)+ u(i-1,j+1)+ u(i+1,j-1) let Δx =1/4 , i=1,2,3 and j=1,2,3

Table 2: HOC Solution

-0.482603517642671 - 2.504601166006421i	-0.482083213366731 - 2.540248895502213i	-0.481500172865038 - 2.581102522601700i
-0.482698884886703 - 2.496846413283060i	-0.482242450112804 - 2.528594563154346i	-0.481634345561261 - 2.569973021872528i
-0.482860209836834 - 2.485041824500299i	-0.482559911858955 - 2.507033797092869i	-0.481979679216937 - 2.544737238975821i

absolute_error2: 0.003265059057445

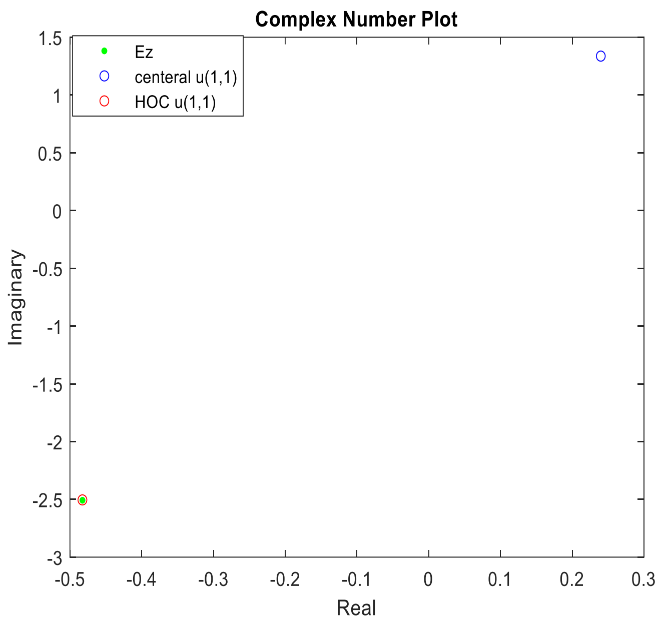

Fig. 2: Comparing between Exact solution, Central Difference Solution& HOC Solution

3.2.2 Magnetic Field in the Ground

3.2.2 .1.Exact solution: for hxg and hyg [5]

Let Hgx=h and Hyg= H

$$H_{xg} = \int_0^\infty F(u)\cos(ux)e^{y\sqrt{u^2+j\alpha}}\frac{\sqrt{u^2+j\alpha}}{j\omega\mu_0}du$$

$$H_{yg} = \int_0^\infty F(u)\sin(ux)e^{y\sqrt{u^2+j\alpha}}\frac{1}{j\omega\mu_0}du$$

$F(u) = \frac{\mu_0}{\pi}\frac{j\omega I e^{-hu}}{\sqrt{u^2+j\alpha+u}}$ and $\alpha = \mu_0\omega/\rho_e$

Δx=Δy= $1 = \delta x$

$E_z(i,k) = 2\,\delta x/\rho_e = M_{(i,k)}$ **i=1,2 and K=1,2**

hxg $92.12159282193053 + 1.3890352006998854i$

hyg $89.37980389978173 - 1.3639880636854207i$

3.2.2 2.Central Difference method: for hxg and hyg System equation are:

$h_{(i+1,k)} - h_{(i-1,k)} + H_{(i,k+1)} - H_{(i,k-1)} = 0 + i0$

$H_{(i+1,k)} - H_{(i-1,k)} - h_{(i,k+1)} + h_{(i,k-1)} = M_{(i,k)}$

At : i=1 , k=1

$h_{(2,1)} - h_{(0,1)} + H_{(1,2)} - H_{(1,0)} = 0$ --------(1)

$H_{(2,1)} - H_{(0,1)} - h_{(1,2)} + h_{(1,0)} = M_{(1,1)}$ (2)

At : i=2 , k=1

$h_{(3,1)} - h_{(1,1)} + H_{(2,2)} - H_{(2,0)} = 0$ (3)

$H_{(3,1)} - H_{(1,1)} - h_{(2,2)} + h_{(2,0)} = M_{(2,1)}$ (4)

At : i=1 , k=2

$h_{(2,2)} - h_{(0,2)} + H_{(1,3)} - H_{(1,1)} = 0$ -----(5)

$H_{(2,2)} - H_{(0,2)} - h_{(1,3)} + h_{(1,1)} = M_{(1,2)}$ (6)

At : i=2 , k=2

$h_{(3,2)} - h_{(1,2)} + H_{(2,3)} - H_{(2,1)} = 0$ ------ (7)

$H_{(3,2)} - H_{(1,2)} - h_{(2,3)} + h_{(2,1)} = M_{(2,2)}$ (8)

Rearrange the equations:

From (6) $h_{(1,1)} + H_{(2,2)} = M_{(1,2)} + H_{(0,2)} + h_{(1,3)}$

From (1) $h_{(2,1)} + H_{(1,2)} = h_{(0,1)} + H_{(1,0)}$

From (2) $h_{(1,2)} - H_{(2,1)} = -M_{(1,1)} - H_{(0,1)} + h_{(1,0)}$

From (4) $h_{(2,2)} + H_{(1,1)} = -M_{(2,1)} + H_{(3,1)} + h_{(2,0)}$

From (5) $-h_{(2,2)} + H_{(1,1)} = H_{(1,3)} - h_{(0,2)}$

From (7) $h_{(1,2)} + H_{(2,1)} = H_{(2,3)} + h_{(3,2)}$

From (8) $-h_{(2,1)} + H_{(1,2)} - M_{(2,2)} + H_{(3,2)} - h_{(2,3)}$

From (3) $-h_{(1,1)} + H_{(2,2)} = H_{(2,0)} - h_{(3,1)}$

Results : Central Difference Solution (Hxg):

101.410334224241964 + 1.394122045424379i

Central Difference Solution (Hyg):

177.732152021410798 -2.717999280335990i

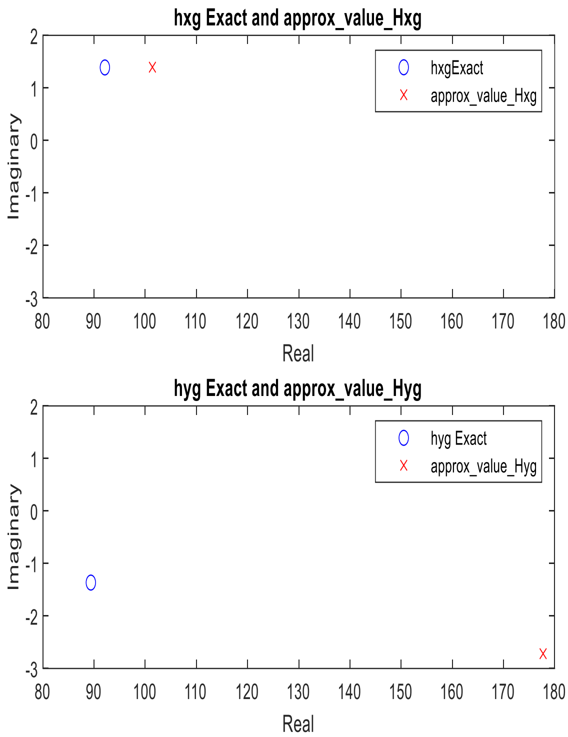

Fig. 3: Comparing between Exact solution, Central Difference Solution Magnetic field (hxg & hyg) absolute_error1 (Hxg) is 9.2887 and absolute_error2(Hyg) is 88.3627

Case II :

The equation 3.21 is come out from subtract both of 3.10 and 3.11 , then using forward difference to approximate the derivative in first order [5] :

$$\frac{\partial f}{\partial x} = \frac{f_{i+1,k} - f_{i,k}}{\Delta x} \quad , \frac{\partial f}{\partial y} = \frac{f_{i,k+1} - f_{i,k}}{\Delta y}$$

$subtract$ 3.10 $from$ 3.11:

$$\frac{\partial H_x}{\partial x} + \frac{\partial H_y}{\partial y} - \left(\frac{\partial H_y}{\partial x} + \frac{\partial H_x}{\partial y}\right) = 0$$

$$\frac{\partial H_x}{\partial x} + \frac{\partial H_y}{\partial y} - \frac{\partial H_y}{\partial x} - \frac{\partial H_x}{\partial y} = 0$$

$$\frac{\partial H_{xi}}{\partial x} + \frac{\partial H_{yi}}{\partial y} + \frac{\partial H_{xi}}{\partial y} - \frac{\partial H_{yi}}{\partial x} = 0\text{------------(I)}$$

$used$ forward difference

$$\frac{H_{xi\,(i,k+1)} - H_{xi\,(i,k)}}{\Delta y} + \frac{H_{xi\,(i+1,k)} - H_{xi\,(i,k)}}{\Delta x} + \frac{H_{yi\,(i,k+1)} - H_{yi\,(i,k)}}{\Delta y} - \left(\frac{H_{yi\,(i+1,k)} - H_{yi\,(i,k)}}{\Delta y}\right) = 0$$

$\Delta x = \Delta y$ now re-arrange : the above equation and using forward difference

$$\frac{\partial H_y}{\partial x} - \frac{\partial H_x}{\partial y} + \frac{\partial H_x}{\partial x} - \frac{\partial H_y}{\partial y} = 0 \text{ then}$$

$$`\frac{\partial H_{yi}}{\partial x} + \frac{\partial H_{yi}}{\partial y} + \frac{\partial H_{xi}}{\partial x} - \frac{\partial H_{xi}}{\partial y} -= 0\text{----(II)}$$

$used$ forward difference and $\Delta x = \Delta y$

$$\frac{H_{yi\,(i+1,k)} - H_{yi\,(i,k)}}{\Delta x} + \frac{H_{yi\,(i,k+1)} - H_{yi\,(i,k)}}{\Delta y}$$

$$+\frac{H_{xi_{(i+1,k)}} - H_{xi_{(i,k)}}}{\Delta x} - \left(\frac{H_{xi_{(i,k+1)}} - H_{xi_{(i,k)}}}{\Delta y}\right) = 0$$

Rearrange after making $\Delta x = \Delta y$
the get equation 3.22[5]

A) Electric Field on Surface:[5]
From curl(E)= - $j\omega\mu_0 H$
using backward difference :

$$\frac{\partial f}{\partial y} = \frac{f_{i,k} - f_{i,k-1}}{\Delta y}$$

$$\frac{\partial E_z}{\partial y} = -j\omega\mu_0 H$$

$$\frac{E_{z_{(i,k)}} - E_{z_{(i,k-1)}}}{\Delta y} = -j\omega\mu_0 H$$

$$\Delta x = \Delta y = \delta x$$

$$E_{z_{(i,k)}} - E_{z_{(i,k-1)}} = -j\delta x\omega\mu_0 H_{xg(i,k)}$$

Then get the equation 3.31

$$E_{z_{(i,k)}} + j\delta x\omega\mu_0 H_{xg(i,k)} - E_{z_{(i,k-1)}} = 0$$

B) Magnetic Field on Surface :
Let $H_{xi} = h \ \ and\ H_{yi} = H$
And system has i=1,2 k= 1,2
<u>From equation 3.21</u>:[5]

$$\boldsymbol{-2\, h_{\mathrm{i,k}} + h_{\mathrm{i,k+1}} + h_{\mathrm{i+1,k}} + H_{\mathrm{i,k+1}} - H_{\mathrm{i+1,k}} = 0}$$

At i=1 , k=1

$$-2\, h_{1,1} + h_{1,2} + h_{2,1} + H_{1,2} - H_{2,1} = 0$$

At i=2 , k=1

$$-2\, h_{2,1} + h_{2,2} + h_{3,2} + H_{2,2} - H_{3,1} = 0$$

At i=1 , k=2

$$-2\, h_{1,2} + h_{1,3} + h_{2,2} + H_{1,3} - H_{2,2} = 0$$

At i=2 , k=2

$$-2\, h_{2,2} + h_{2,3} + h_{3,2} + H_{2,3} - H_{3,2} = 0$$

<u>From equation 3.22:</u>[5]

$$\boldsymbol{-2\, H_{\mathrm{i,k}} + h_{\mathrm{i+1,k}} - h_{\mathrm{i,k+1}} + H_{\mathrm{i+1,k}} + H_{\mathrm{i,k+1}} = 0}$$

At i=1 , k=1

$$-2\, H_{1,1} + h_{2,1} - h_{1,2} + H_{2,1} + H_{1,2} = 0$$

At i=2 , k=1

$$-2\, H_{2,1} + h_{3,1} - h_{2,2} + H_{3,1} + H_{2,2} = 0$$

At i=1 , k=2

$$-2\, H_{1,2} + h_{2,2} - h_{1,3} + H_{2,2} + H_{1,3} = 0$$

At i=2 , k=2

$$-2\, H_{2,2} + h_{3,2} - h_{2,3} + H_{3,2} + H_{2,3} = 0$$

1. Calculate Electric Field in Surface:
and Rearrange [5]

$$E_{z_{(i,k)}} - E_{z_{(i,k-1)}} = -j\delta x\omega\mu_0 H_{xg(i,k)}$$

Then

$$\boldsymbol{E_{z_{(i,k)}} + j\delta x\omega\mu_0 H_{xg(i,k)} - E_{z_{(i,k-1)}} = 0}$$

At i=1 , k=1

$$E_{z_{(1,1)}} + j\delta x\omega\mu_0 H_{xg(1,1)} - E_{z_{(1,0)}} = 0$$

At i=2 , k=1

$E_{z(2,1)} + j\delta x\omega\mu_0 H_{xg(2,1)} - E_{z_{(2,0)}} = 0$

At i=1 , k=2

$E_{z(1,2)} + j\delta x\omega\mu_0 H_{xg(1,2)} - E_{z_{(1,1)}} = 0$

At i=2 , k=2

$E_{z(2,2)} + j\delta x\omega\mu_0 H_{xg(2,2)} - E_{z_{(2,1)}} = 0$

Where the $H_{xg(i,k)}$ is total magnetic field from [5]**:**

$H_{xg(i,k)} = H_{xc(x,y)} + H_{xi(x,y)} = \frac{(h-y)I}{2\pi(x^2+(h-y)^2} + \int_0^\infty \phi(u)\cos(ux)e^{-yu}\,du$

While : $\phi(u) = \frac{I\,e^{-hu}(\sqrt{u^2+j\alpha}-u)}{(\sqrt{u^2+j\alpha}+u)}$

4 Analysis of the Results:

1.Calculate the Electric field intensity in ground: **A- Electric field intensity (E):**

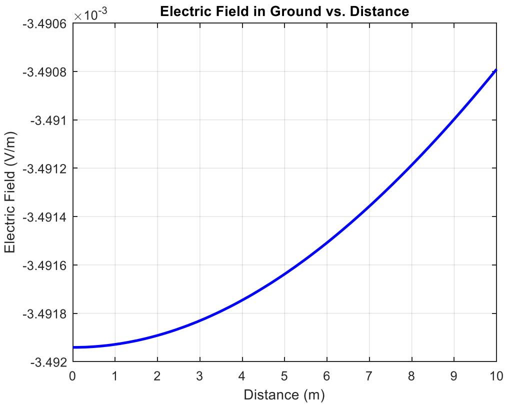

Fig. 4: Maximum Electric field intensity in ground is 0.50771 V/m

B- i))Magnetic field intensity (H) Hxg,Hyg in ground:

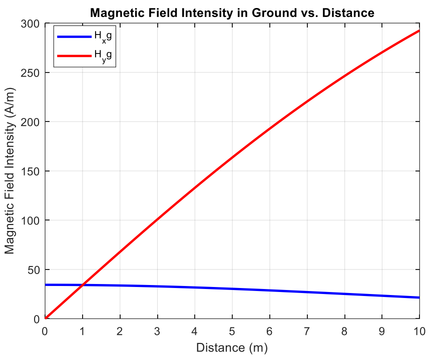

Figure 5: Maximum Magnetic Field Intensity (H_xg): 34.4087 A/m , Maximum Magnetic Field Intensity (H_yg): 292.5003 A/m in ground

ii)Total Magnetic Field Intensity(H) in ground:

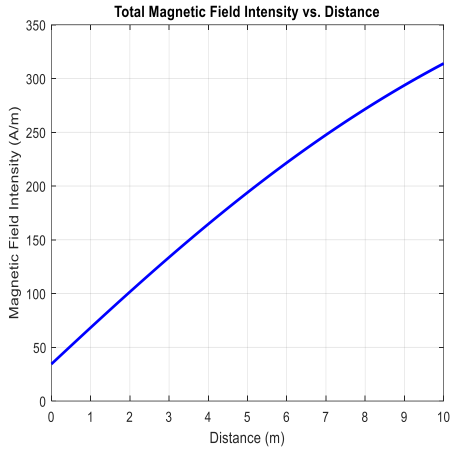

Fig. 6: Total Magnetic Field Intensity 313.9507 A/m in ground

2.Calculate the Electric field intensity on surface:[10] Electric power is continuously growing for generation and distribution ,it have advanced significantly as reducing the size of electric generators, incorporating renewable energy into the generating sector, and distributing electricity using power electronics are a few of these strategies. Transmission lines, on the other hand, are an exception to this to calculate the Electric field intensity on surface.

A- Electric field intensity (E):

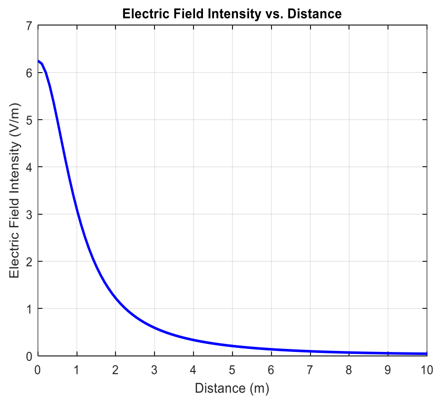

Fig. 7: Electric field intensity (E) on surface respect to distance (meters)

Table 3: Electric field intensity (E) on surface respect to distance

E_Intensity V/m	Distance (meters)	E_Intensity V/m	Distance (meters)
6.2463	0	0.20339	5.00
6.1829	0.10	0.19467	5.10
6	**0.20**	0.18644	5.20
5.7179	0.30	0.17866	5.30
5.3646	0.40	0.1713	5.40
4.9694	0.50	0.16434	5.50
4.5585	0.60	0.15774	5.60
4.1521	0.70	0.1515	5.70
3.7643	0.80	0.14557	5.80
3.4034	0.90	0.13995	5.90
3.0733	1.00	0.13461	6.00
2.7751	1.10	0.12953	6.10
2.5079	1.20	0.12471	6.20
2.2697	1.30	0.12013	6.30
2.0579	1.40	0.11576	6.40
1.8699	1.50	0.11161	6.50

1.703	1.60	0.10766	6.60
1.5547	1.70	0.10389	6.70
1.4228	1.80	0.1003	6.80
1.3052	1.90	0.096885	6.90
1.2002	2.00	0.093626	7.00
1.1062	2.10	0.090519	7.10
1.0218	2.20	0.087555	7.20
0.94591	2.30	0.084729	7.30
0.87748	2.40	0.082034	7.40
0.81561	2.50	0.079463	7.50
0.75955	2.60	0.077012	7.60
0.70863	2.70	0.074673	7.70
0.66226	2.80	0.072443	7.80
0.61995	2.90	0.070317	7.90
0.58125	3.00	0.06829	8.00
0.54578	3.10	0.066358	8.10
0.51321	3.20	0.064517	8.20
0.48324	3.30	0.062763	8.30
0.4556	3.40	0.061093	8.40
0.43008	3.50	0.059504	8.50
0.40646	3.60	0.057992	8.60
0.38457	3.70	0.056554	8.70
0.36425	3.80	0.055188	8.80
0.34536	3.90	0.05389	8.90
0.32777	4.00	0.052658	9.00
0.31136	4.10	0.05149	9.10
0.29604	4.20	0.050383	9.20
0.28172	4.30	0.049335	9.30
0.26831	4.40	0.048343	9.40
0.25574	4.50	0.047406	9.50
0.24395	4.60	0.046522	9.60
0.23287	4.70	0.045687	9.70
0.22244	4.80	0.044901	9.80
0.21263	4.90	0.044162	9.90

B- i) Magnetic field intensity (H) Hxg,Hyg on surface::

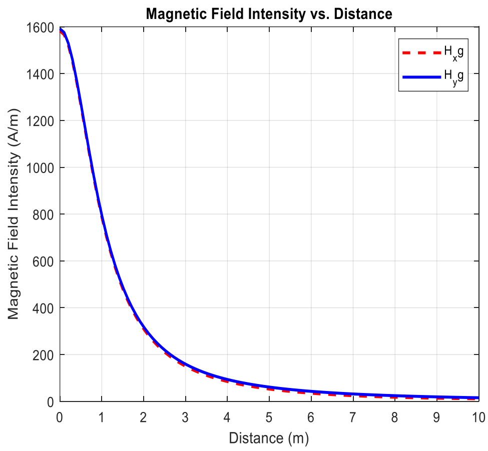

Fig. 8: Maximum magnetic field intensity (H_xg) is 1582.2181 A/m & (H_yg) is 1591.5494 A/m on surface:

ii)Total Magnetic Field Intensity(H) on surface:

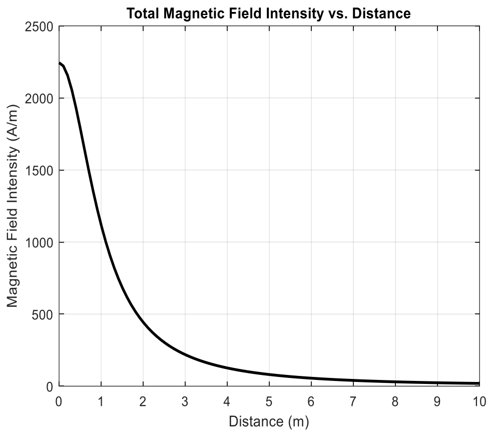

Fig. 9: Maximum magnetic field intensity (H_total)=2244.2022 A/m

Conclusion:

This paper compares a finite difference method computational scheme for evaluating electromagnetic field problems in power transmission lines. The scheme uses Maxwell's partial differential equations to represent electric and magnetic field components and approximate boundary conditions. HOC given more accurate results than the traditional central approximation at 99.7% for the electric field Ez. then calculates both of Electric and magnetic intensity in ground which showing that increasing by increase the distance toward the surface while both of Electric and magnetic intensity on surface respect to distance are decrease by increase the distance along the surface.

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