

# Fast Algorithm for Passive Interference of UHV Transmission Lines

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**Abstract:** Passive interference analysis of transmission lines to radio stations is almost entirely based on the method of moments (MOM) or the rapid multipole method and multi-layer fast multipole method (FMM) developed by the method of moments. Based on the above algorithm, this paper proposes to use a diffraction model (UTD) and an optical diffraction method (PO) to model different transmission lines with different radii. The calculation results show that the difference of field strength generated by transmission lines with different radii varies with the distance of the observation point on the transmission line, and the accuracy of the UTO method is much smaller than that of the PO method. It can make good results that provides technical foundation for future modeling.

## 1 Introduction

In recent years, with the rapid development of science and technology, massive construction of infrastructure such as transmission lines and radio stations has led to a close distance between the above two<sup>[1]</sup>. In this case, even if the transmission line is not live working, its huge metal structure will affect the reception or transmission of signals from nearby radio stations, which leads to the increasing electromagnetic radiation from transmission lines to radio stations. Therefore the problem that must be considered in power line construction is how to determine the reasonable distance between transmission line and radio station or reduce the passive interference of them.

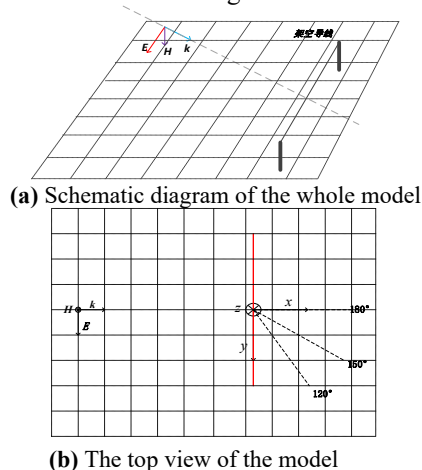
To solve this problem, the United States<sup>[4-6]</sup>, Canada<sup>[7]</sup>, Japan<sup>[8,9]</sup> and other countries have carried out related research on the influence of power lines on signals in different frequency bands such as MF, VHF/UHV, and m waves since 1960s, which involves radio wide broadcast<sup>[7]</sup>, radar navigation<sup>[5-9]</sup> and other fields<sup>[8]</sup>. Since the construction of UHV transmission lines in China, the electric field strength characteristics of UHV transmission lines have a more in-depth research.

According to the working mode and working frequency of radar, the fast multipole method and multi-layer fast multipole method(FMM) developed by the moment method are used, and the diffraction model (UTD) and optical diffraction method (PO) are adopted. The passive interference generated by different transmission lines with different radius is solved and analyzed

## 2 Modeling

### 2.1 Model establishment

In the calculation, in order to simulate the influence of the transmission line on the radar operation, it is assumed that the electromagnetic wave direction ( $k$ ) emitted by the radar is perpendicular to the transmission line, the electric field strength ( $E$ ) is parallel to the overhead transmission line, and the electric field strength is 1V/m(0dBV/m), the calculation model is shown in Figure 1.



**Fig.1** Passive interference computing model of overhead conductors

### 2.2 Frequency selection

The air-to-air intelligence radar studied in this paper is the commonly used model in China. According to the range from low to high, in the analysis, select 4 frequency points

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of 0.23GHz, 1GHz, 2GHz and 4GHz to calculate.

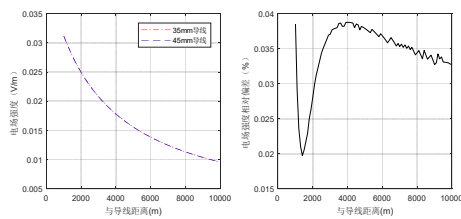
### 3 Influence of wire radius on electric field strength

In the above modeling case, referring to the wire radius of the UHV AC-DC transmission line, the variation law of the electric field strength under the two modeling modes of the transmission line radius of 35mm and 45mm is calculated respectively.

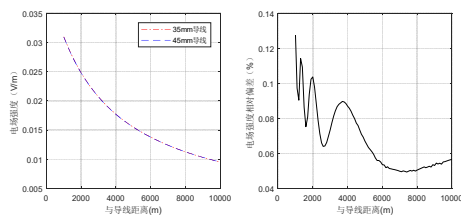
The other main conditions are as follows:

- (1) the length of the wire is 100m;
- (2) calculate the point from 1000m away from the wire to 10 km.

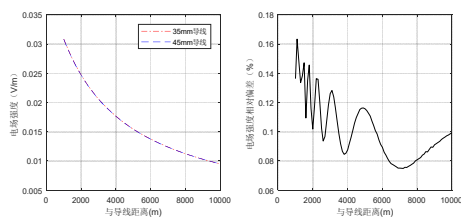
The calculation results of passive interference under different wire radius are shown in Figure 2.



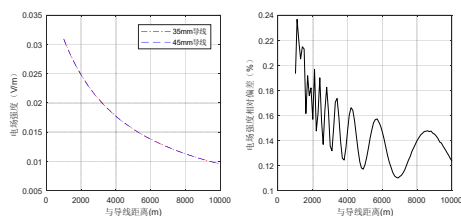
(a) Electric field strength at each point of the vertical line at the frequency of 0.23 GHz



(b) Electric field strength at each point of the vertical line at the frequency of 1 GHz



(c) Electric field strength at each point of the vertical line at the frequency of 2 GHz



(d) Electric field strength at each point of the vertical line at the frequency of 4 GHz

**Fig.2** Electric field strength at each point of the vertical line under different radius and different frequencies

From the above figure, we can draw the following conclusions:

Under the same frequency condition, the electric field strength of the transmission line under the different wire radius is basically the same as the distance curve between the observation point and the transmission line, and the

deviation of the distance is smaller. According to the trend of the curve, the maximum deviation is less than 0.5% outside of 1km.

### 4 Comparison of results of different algorithms

According to the above conclusion that the difference of sub-wire radius has little effect on radar passive interference, and considering the limitations of the computer, this section uses a transmission line with a radius of 35mm for calculation.

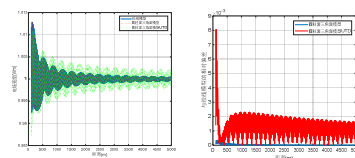
#### 4.1 Comparison of calculation results between FMM and UTD

The passive interference analysis of transmission lines to radio stations is almost entirely based on the method of moments (MOM) or the rapid multipole method and multi-layer fast multipole method (FMM) developed by the method of moments, it is also possible to model calculations using Uniform Diffraction Model (UTD). This section compares the difference between the calculation results of the fast multipole method and the uniform diffraction (UTD). The calculation methods of the cylindrical triangular surface model are FMM and UFO, respectively, and the twisted line model is the reference model of the above comparison.

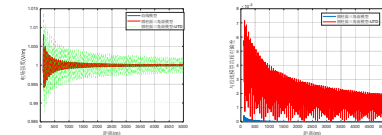
The main conditions are as follows:

- (1) the length of the wire is 100m;
- (2) calculate the point from 100m away from the wire to 5km.

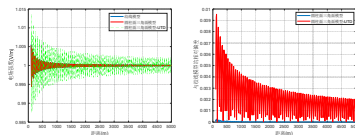
The calculation results of the spatial electric field strength under different calculation methods are shown in Figure 3.



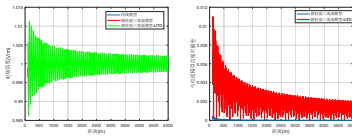
(a) Electric field strength at each point of the vertical line at the frequency of 0.23 GHz



(b) Electric field strength at each point of the vertical line at the frequency of 1 GHz



(c) Electric field strength at each point of the vertical line at the frequency of 2 GHz



(d) Electric field strength at each point of the vertical line at the frequency of 4 GHz

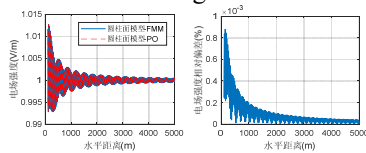
**Fig.3** Comparison of calculation results between FMM and UTD

From the above figure, we can draw the following conclusions:

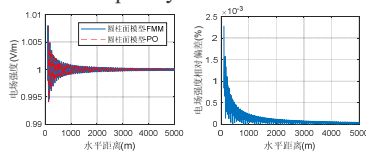
Under the same frequency condition, the electric field strength of the transmission line is basically the same as the distance curve between the observation point and the transmission line under different wire models, and the deviation of the distance is smaller. However, as the frequency increases, the difference in electric field strength obtained by the two calculation methods will gradually increase, and the relative deviation of the electric field strength from the stranded model will also increase. This shows that it is not accurate to calculate the far field of overhead lines by consistent diffraction.

#### 4.2 Comparison of calculation results between FMM and PO

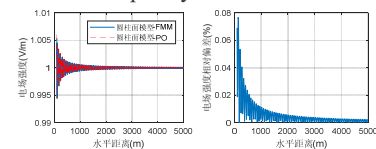
Considering the high frequency calculation problem in the calculation of this paper, the optical diffraction method (PO) modeling calculation can also be used. Therefore, this section compares the difference between the calculation results of the fast multipole method and the optical diffraction method (PO), and gives a comparison of the spatial electric field strength from 100m to 5000m.



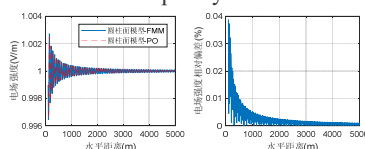
(a) Electric field strength at each point of the vertical line at the frequency of 0.23 GHz



(b) Electric field strength at each point of the vertical line at the frequency of 1 GHz



(c) Electric field strength at each point of the vertical line at the frequency of 2GHz



(d) Electric field strength at each point of the vertical line at the frequency of 4GHz

**Fig.4** Comparison of calculation results between FFM and PO

From the above figure, we can draw the following

conclusions:

Under the same frequency, the electric field strength of the transmission line is basically the same as the trend of the distance between the observation point and the transmission line under different wire models, showing that the deviation of the distance is smaller, and the electric field strength obtained by the two calculation methods is almost the same.

This is consistent with the principle of the physical optical diffraction method that is more suitable for far-field calculations. According to the trend of the curve in the figure, it can be inferred that at any frequency point, the area outside the 1km, the maximum deviation in value does not exceed 0.02%. This shows that it is accurate to calculate the far field of overhead lines by means of physical optical diffraction.

## 5 Conclusion

Passive interference analysis of transmission lines to radio stations is almost entirely based on the method of moments (MOM) or the rapid multipole method and multi-layer fast multipole method (FMM) developed by the method of moments. Based on the above algorithm, this paper proposes to use a diffraction model (UTD) and an optical diffraction method (PO) to model different transmission lines with different radius. Concluded as follow:

(1) Under the same frequency condition, the electric field strength of the transmission line under the different wire radius is basically the same as the distance curve between the observation point and the transmission line, and the deviation of the distance is smaller. According to the trend of the curve, the maximum deviation is less than 0.5% outside of 1km.

(2) In the case of the same wire radius, when the frequency is different, the electric field strength of the transmission line is basically the same as the distance curve between the observation point and the transmission line, and the deviation of the distance is smaller. However, as the frequency increases, the difference in electric field strength obtained by the FMM and UTD will gradually increase, and the relative deviation of the electric field strength from the stranded model will also increase. This shows that it is less accurate to calculate the far field of an overhead line by UTD. In this case, the electric field strength obtained by the FMM and PO is almost the same, and the algorithm principle of the far-field calculation is more consistent with the PO. And at any frequency point, the area outside the 1km, the maximum deviation in value does not exceed 0.02%. This shows that it is accurate to calculate the far field of the transmission line by means of physical optical diffraction.

## Acknowledgement

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## References

1. Yin hui, Zhang xiaoming, Wang yantao, et al. Research on 3D visualization of electromagnetic interference for Ultra-high Voltage transmission lines. *High Voltage Engineering*,**40**,12 (2014)
2. Tang bo , Yang jiawei, Huang li, et al. Guard spacing of the air surveillance radar station to Ultrahigh Voltage transmission line.**40.4**(2018)
3. Tang bo, Sun rui, Zhao xiaoming, et al. Three-dimensional Surface Computation model of the Reradiation interference From UHV angle-steel Tower [J]. *Proceedings of the CSEE*, **31**, 4, 2011.
4. Wu xiong, Wan baoquan, Zhang xiaowu, et al. Study on the influence and protection of the radio station between the two circuits of the 1000kV high voltage exchange [R] .Wuhan, Hubei: Wuhan institute of high pressure, 2008.
5. Hill P C.Measurement of reradiation from lattice masts at V.H,F.[J].*Proc Inst Elec Eng*,111,121964.
6. Kamal Sarabandi, Moonsoo Park. A radar cross-section model for power lines at millimeter-wave frequency[J].*IEEE Transactions on Antenna and Propagation*, 2003,**51**(9):2353-2360
7. Truemen C W, Kubina S J. Scatting from power lines with the sky wire insulated from the towers [J].*IEEE Transactions on Broadcasting*, 1994,**40** (2):53-62.
8. Kinase. Theoretical analysis of reradiation characteristics of radio wave caused by transmission lines[ J] .*NHK Technology Research* , 1968 , **20**(3):42-48
9. Takeshita K, Takeshita S, Hashimoto H. Scattering characteristics of VHF/UHF television broadcasting waves by overhead owner transmission conductors[J]. *Transactions on Electromagnetic Compatibility*,1979,**21**(1):33-40