

Engineering Application Research of Radio Wave Transmission Model in The Mountainous Region

Na Deng, Xun Ding and Xu Tan

Abstract. Common terrain is mountainous in southern China, this terrain to the transmission coverage Engineering brings certain challenges, How to take advantage of existing knowledge combined with practical engineering experience to sum up a set of calculation methods suiting for mountainous areas, that is very conducive to saving investment in transmission coverage, in this paper combining the Proposal (ITU-R P.526) and using Bullington method and Epstein-Peterson method. In addition, the author proved that this radio wave propagation model has certain reference value on whole control of FM broadcasting through computation simulation of ICS telecom software and comparison between Google Maps and actually measured data.

Keywords: FM broadcasting, radio wave propagation model, Bullington method, Epstein-Peterson method, blade-peak diffraction

1.1 Introduction

FM broadcasting band is from 87 MHz to 108MHz. It is easy for radio wave to generate diffraction in complex terrain, because its wave length is within the scope of nanometer. Research areas in this thesis are hilly areas, so diffraction is an important factor which must be considered at the time of analyzing coverage quality, when propagation covering is conducted.

¹ Na Deng (✉)

Modern Education Technology Center of Hunan Communication Polytechnic

China, 410000, Changsha

e-mail: 179323906@qq.com、

Xun Ding

Hunan People's Broadcasting Station

Changsha, 41000 ,China

Xu Tan

Hunan People's Broadcasting Station

Changsha, 41000 ,China

International Telecommunication Union (ITU) formulated I T U-R P.526 proposal - Propagation by Diffraction in 1978, where diffraction influences during propagation and forecasting methods of field intensity are mainly described. In forecasting, besides considering diffraction caused by rugged terrain, it also involves diffraction influences of sphere surface of the earth on propagation. However, only single-blade peak, two-blade peak and single-round peak conditions are offered in this proposal, and general solutions aiming at complex terrain are not put forward. In the thesis, the author discussed the Proposal (ITU-R P.526) with the combination of Bullington method and Epstein-Peterson method, simulated covering effects of FM broadcasting towards specific areas with multi-blade-peak diffraction with the use of ICS telecom software, and verified effectiveness of suggested radio wave propagation model through contrastive analysis of actually measured data.

1.2 ITU-R P.526 Principle

When the shape of single barrier is complex, it is difficult to give accurate analytical solution. Only when there are two single barriers with different shapes, complete analytical solution can be given: one is the blade peak (refer to Fig.1 and Fig.2) whose thickness can be ignored; the other is cylinder barrier whose surface is smooth (refer to Fig.3).

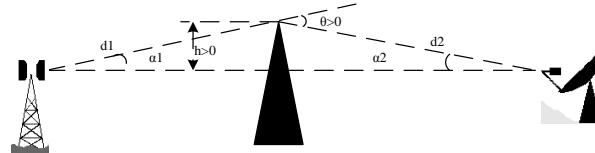


Fig.1 Schematic Diagram for Diffraction of Single-Blade Peak (a)

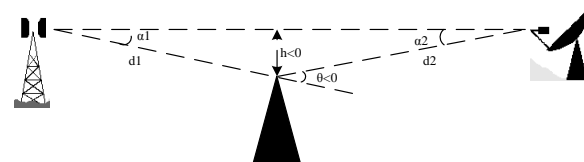


Fig.2 Schematic Diagram for Diffraction of Single-Blade Peak (b)

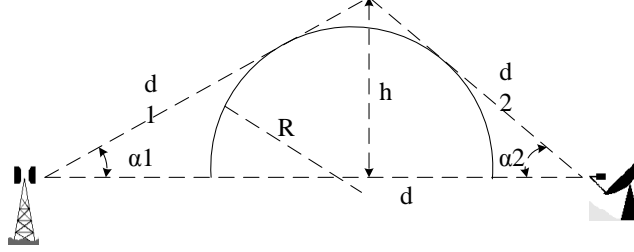


Fig.3 Schematic Diagram for Diffraction of Single-round Peak

Under the condition of single-blade peak, only one barrier on the propagation path causes loss to propagation, and influences generated by this barrier can be computed according to the following two equations:

$$v = h \sqrt{\frac{2}{\lambda} \left(\frac{1}{d_1} + \frac{1}{d_2} \right)} \quad (1)$$

$$J(v) = 6.9 + 20 \log \left(\sqrt{(v - 0.1)^2 + 1} + v - 0.1 \right) dB \quad (2)$$

Parameter meanings in these equations are shown in Fig.1 and Fig.2. Under the condition of single-round peak, only one round barrier on the propagation path has influences to propagation. Furthermore, it is necessary to add a correction factor in the process of calculating loss, and this correction factor is supplied by the following equation:

$$T(m, n) = km^b \quad (3)$$

Thereinto

$$k = 8.2 + 12.0n, b = 0.73 + 0.27[1 - \exp(-1.43n)],$$

$$m = R \left[\frac{d_1 + d_2}{d_1 d_2} \right] / \left[\frac{\pi R}{\lambda} \right]^{1/3}, n = h \left[\frac{\pi R}{\lambda} \right]^{2/3} / R.$$

Parameter meanings in these equations are shown in Fig. 3.

1.2 ITU-R P.526 Principle

Two-blade-peak diffraction is the simplest multi-peak diffraction. We can gain two-blade-peak diffraction generated by double barriers through double integral of Fresnel's Formula, but huge calculated amount may reduce its timeliness in prac-

tical application, while this problem is solved well by Bullington method and Epstein-Peterson method with the use of equivalent method.

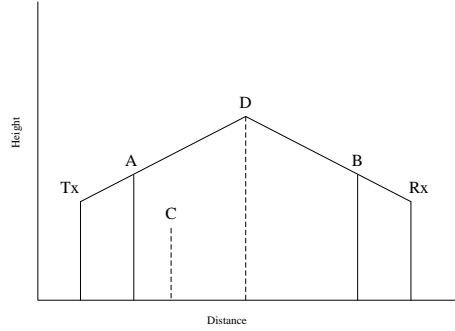


Fig.4 Schematic Diagram of Bullington Method

In Bullington method, barriers at point A, B, and C are replaced by an equivalent blade-shape barrier in the junction of D, and at this time, barriers at point A and B can be ignored, which is shown in Fig.4.

In Epstein-Peterson method, abh_1 and bch_2 can compose single-blade peak, which is shown in Fig.5. Calculate the diffraction loss L_1 between abh_1 , and then calculate the diffraction loss L_2 between bch_2 . It is necessary to add a correction factor L_c after calculating L_1 and L_2 , whose computational formula is as follows:

$$L_c = 10 \log \left[\frac{(a+b)(b+c)}{b(a+b+c)} \right] \quad (4)$$

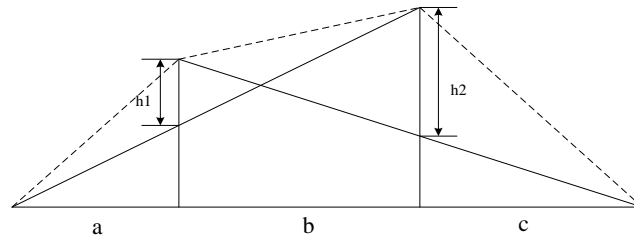


Fig.5 Schematic Diagram of Epstein-Peterson Method

Therefore, total diffraction loss is:

$$L = L_1 + L_2 + L_c \quad (5)$$

There are generally several propagation paths at the time of forecasting and calculating propagation of mountainous areas. Under the circumstances, diffraction loss can be calculated only through making multi-blade peak equal to single-blade peak or two-blade peak. We can make several blade peaks equal one by one with the use of Bullington method, to gain equivalent single-blade peaks and to calculate total propagation losses. What's more, we can also make them equal one by one with the use of Epstein-Peterson method. However, in the two-blade peak processing method offered by Epstein-Peterson, the longer the barrier distance is, the more accurate the gained result is; the shorter the barrier is, the less accurate the gained result is. Therefore, it is necessary to limit the number of blade peaks at the time of building blade peaks, and we shall consider blade peaks with larger influences to diffraction.

1.2 Experiment Simulation

In order to enhance accuracy of radio wave propagation forecasting, on one hand, people try to find accurate analytical solution of diffraction in theoretical calculation, on the other hand, people want to summarize regular propagation forecasting curve through a good deal of actually measured data as ITU-R P.370 and ITU-R P.1546. In addition, achievements in these two aspects are mainly reflected in the Proposal (ITU-R P.526).

Select special areas around a launcher in Changsha as a reference, and parameters of this launcher are as follows (as shown in Table 1):

Table 1 Parameters of a Launcher

	Longitude and latitude	Elevation	Antenna height	Condition power of transmitter	Antenna specification
er Launcher	N28°13' 9.37" E112°59 '41.96"	50 m	150 m	10KW	4-floor 4-surface horizontal array (share)

It is thus clear in Fig.6 that there are multi-blade-peak terrains in the northwest and southwest, with obvious diffraction when radio wave meets blades for the first time. With extension of mountainous areas respectively, height and radius are increased to some extent. We can know that mountains' height and radius play a decisive role in effects of radio wave diffraction, as shown in equation (2) and (3). The ability of radio wave diffraction has almost died out. It can be seen in

Fig.7 that measurement effects of extended parts behind the mountain are not very ideal. ITU-R P.526 multi-peak diffraction model forecasts radio wave propagation in mountainous areas in whole regional coverage, which can be seen in Fig.8.

Electronic map must be combined in the process of handling multi-peak diffraction with the use of ITU-R P.526, so that it can forecast accurately. However, in electronic maps, it is very professional to build and to collect geographic information parameters which are necessary for calculation. Whether the first Fresnel area is obstructed or not, obstruct degree, structure of blade peak, distinguish and equivalence are cores for handling this problem

It should be noted when TV FM broadcasting band applies the Proposal (ITU-R P.526), such physiographic barriers as mountain peaks or hills are main barriers to be considered, which doesn't involve influences of high buildings. It is necessary for experts in the industry to discuss further how to calculate and to forecast diffraction influences of high buildings through applying the Proposal (ITU-R P.526).

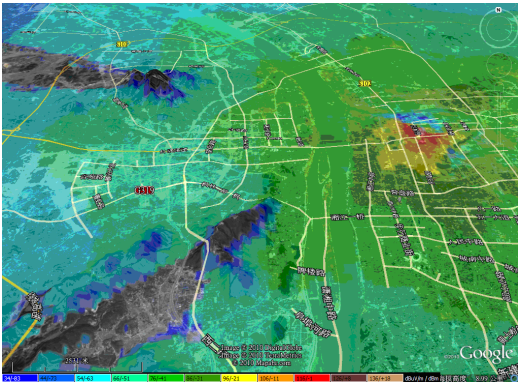


Fig.6 ICS Telecom Simulation Design Sketch

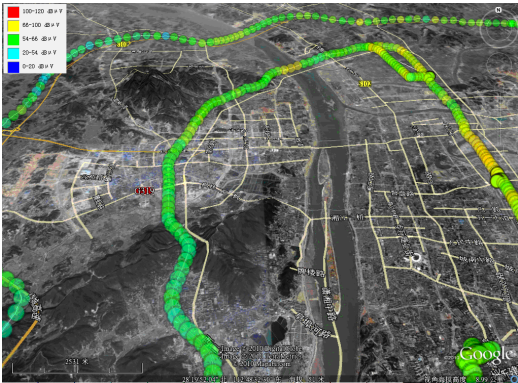


Fig.7 Accurately Measured Design Sketch

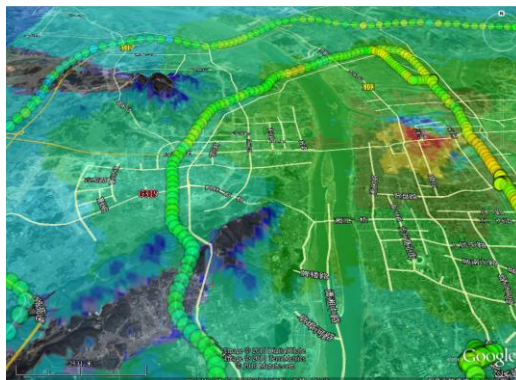


Fig.8 Simulation and Measured Design Sketch

1.3 Conclusions

In the thesis, the author researched ITU-R P.526 radio wave propagation model, discussed multi-blade peak diffraction aiming at the characteristic of multi-blade-peak diffraction of hilly areas, on the basis of original model, and with the combination of Bullington method and Epstein-Peterson method. Finally, the author realized simulating calculation of ITU-R P.526 radio wave propagation model in hills with the use of ICS telecom software and conducted comparative analysis with the combination of Google Maps and actually measured data. Simulation results coincide with actually measured results well, as shown in Fig.8. It can be seen that ITU-R P.526 radio wave propagation model has great reference value on the forecast of multi-blade peak diffraction.

1.3 References

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