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Significance of Increasing the Receive Antenna Height in Reducing Path Loss for Hata Path Loss Model

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Abstract- This letter shows a significant improvement procedure to reduce the path loss for Hata Path Loss model. This can be applied for urban, suburban and open areas in different frequencies. This is completely a software based approach to determine a relation between the path loss and the height of the receive antenna. Here it is shown that if the height of receive antenna is increased then the path loss decreases significantly.

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I. INTRODUCTION

In wireless communication fading refers to a very unique characteristic. The variation of the signal amplitude over time and frequency is called fading. There are two types of fading, one is large scale fading and the other is small scale fading. Large scale fading comprises of path loss and shadowing. Hata model is one of the most adopted path loss models that can predict path loss in urban, suburban and open area. Here it is shown that if the height of receive antenna is increased then the path loss decreases significantly. Here the height of the transmit antenna is set to 30m and carrier frequencies used are 1500 MHz and 200 MHz.

a) Hata Model

Among many other radio propagation models, Hata model is currently the most popular path loss model. For the height of transmit antenna, h_{TX} [m], and the carrier frequency of f_c [MHz], the path loss at distance d [m] in an urban area is given by the Hata model as:

$$PL_{Hata, U}(d)[dB] = 69.55 + 26.16 \log f_c - 13.82 \log h_{TX} - C_{RX} + (44.9 + 6.55 \log h_{TX}) \log d.$$

Where, C_{RX} is the correlation coefficient of the receive antenna, which depends on the size of coverage. For small to medium-sized coverage, C_{RX} is given as

$$C_{RX} = 0.8 + (1.1 \log f_c - 0.7) h_{RX} - 1.56 \log f_c$$

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Where, h_{RX} [m] is the height of transmit antenna. For large-sized coverage, C_{RX} depends on the range of the carrier frequency, for example,

$$C_{RX} = 8.29 (\log (1.54 h_{RX}))^2 - 1.1 \text{ if } f_c \text{ is in between } 150 \text{ MHz} - 200 \text{ MHz}$$

$$C_{RX} = 3.2 (\log (11.75 h_{RX}))^2 - 4.97 \text{ if } f_c \text{ is in between } 200 \text{ MHz} - 1500 \text{ MHz}$$

Meanwhile, the path loss at distance d in suburban and open areas are respectively given by the Hata model as

$$PL_{Hata, SU}(d)[dB] = PL_{Hata, U}(d) - 2 (\log f_c / 28)^2 - 5.4$$

$$PL_{Hata, O}(d)[dB] = PL_{Hata, U}(d) - 4.78 (\log f_c)^2 + 18.33 \log f_c - 40.97$$

As in the urban area there are lots of obstructions like multistoried building or towers, therefore urban area possess more path loss than suburban and open area with the increase of distance between base station and mobile station. Open area have less obstructions and therefore less path loss than urban and suburban area.

Now it will be shown that if the height of the receive antenna is increased then the path loss decreases using MATLAB simulation.

II. SIMULATION

Several simulations are done to establish the concept which is proposed in this paper. At first the height of the transmit antenna is set to 30 [m] and carrier frequency is set to 1500 MHz. The height of the receive antenna will be varied from 2 [m] to 50 [m]. Now the generated output curves of path loss versus distance for urban, suburban and open area are shown in Fig. 1, Fig. 2, Fig. 3, Fig. 4, Fig. 5 and Fig. 6.

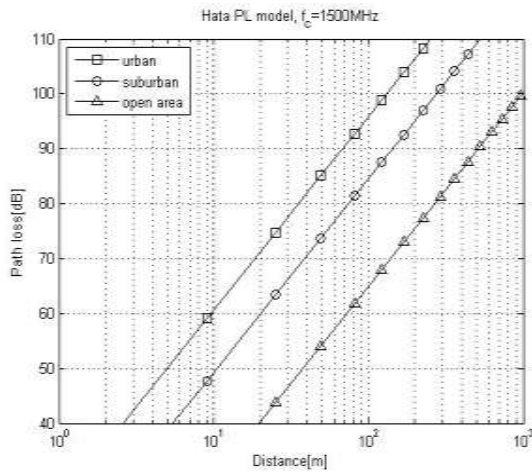


Figure 1 : Path loss vs. distance curves when receive antenna height is 2 [m]

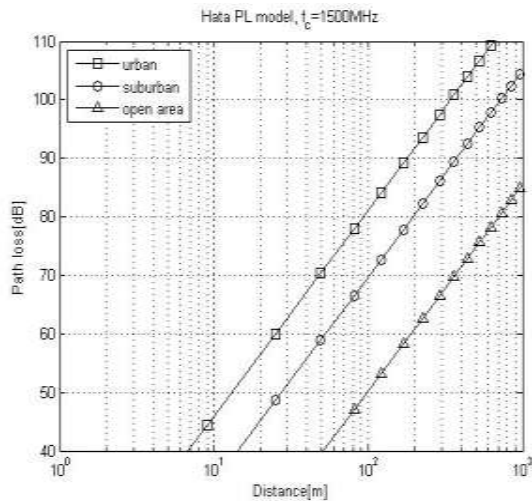


Figure 2 : Path loss vs. distance curves when receive antenna height is 30 [m]

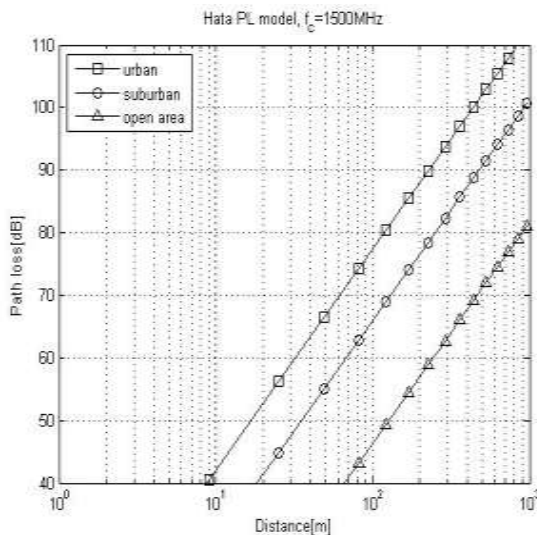


Figure 3 : Path loss vs. distance curves when receive antenna height is 50 [m]

Now the frequency is changed to 200 MHz keeping the transmit antenna height unchanged. Again for different heights of the receive antenna several path loss versus distance curves are generated.

The generated output curves are shown in Fig. 4, Fig. 5 and Fig. 6.

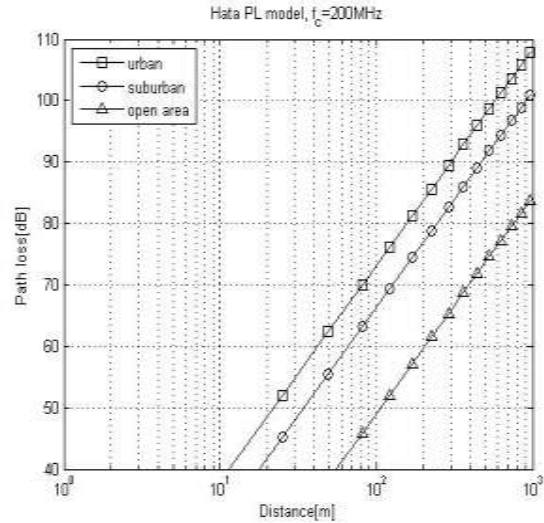


Figure 4 : Path loss vs. distance curves when receive antenna height is 2 [m]

It can also be said that for same value of transmit and receive antenna height, path loss decreases after reducing the value of carrier frequency.

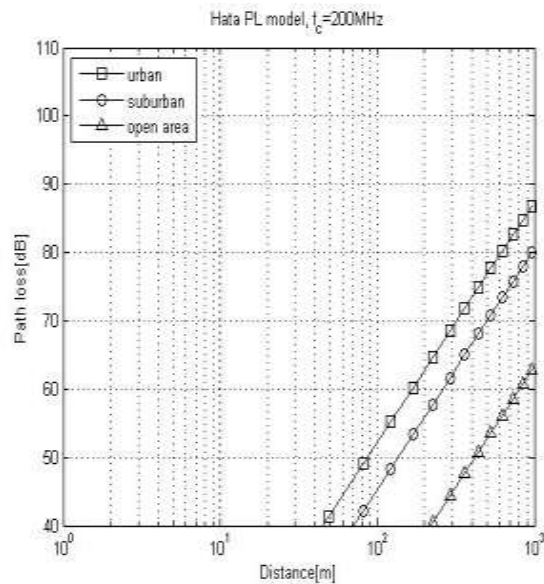


Figure 5 : Path loss vs. distance curves when receive antenna height is 30 [m]

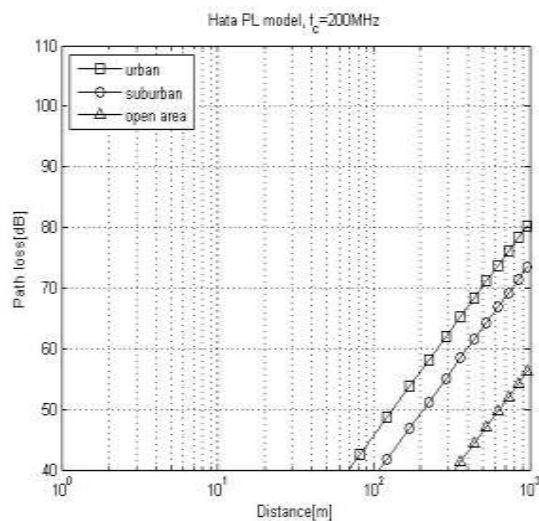


Figure 6 : Path loss vs. distance curves when receive antenna height is 50 [m]

III. DISCUSSION

Simulation is done for different heights of receive antenna. Figure. 1, Fig. 2 and Fig. 3 are generated for a carrier frequency of 1500 MHz. We could see that path loss decreases with the increase of receive antenna height. Say for example, in Fig. 1, when distance is 100 [m] then path losses are around 97, 85 and 65 [dB] for urban, suburban and open area, respectively. But these values decrease in Fig. 2 and Fig. 3 for the same distance. In Fig. 3, path losses become around 78, 67, 47 [dB] for the same distance of 100 [m]. Figure. 4, Fig. 5 and Fig. 6 are generated for a carrier frequency of 200 MHz.

In Fig. 4, when distance is 100 [m] then path losses are around 72, 68 and 49 [dB] for urban, suburban and open area, respectively. But these values decrease in Fig. 5 and Fig. 6 for the same distance. In Fig. 6, path losses become around 47, 0, 0 [dB] for the same distance of 100 [m] which is a significant improvement.

IV. CONCLUSIONS

In this paper we tried to show the relation between the path loss and the height of receive antenna. It is evident that, path loss decreases with the increase of receive antenna's height. But in practice, this is not quite feasible enough in case of our cell phone. Because it is not possible to increase the height of its antenna to a significant amount as it will increase the cell size and weight. That is why sometimes external antennas are provided with the cell phones. So, the height of receive antenna should be increased to reduce the path loss to a significant amount.

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