Multipath Fading Characteristics of Millimeter Wave Radio Propagation in Urban Microcellular Environment

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Abstract - **The frequency region 28-38 GHz has potential applications in fixed-wireless broadband services on account of availability of large spectrum and adequate device support to ease spectrum congestion problems, particularly in urban centers. This paper envisages development of a multiray propagation model to investigate multipath fading prevailing in millimeter wave radio propagation in a micro cellular environment. The model is simulated and measurements are carried out to estimate fast fading, propagation loss, and delay spread along micro cellular streets of variable width. The results depicted in the paper yields quantitative trends, with specific use in planning radio cells for fixed- wireless broadband services in urban microcellular environment.**

Index Terms - Fading, microcellular, multipath, milimeter wave, fading.

I. INTRODUCTION

The study of millimeter waves in perspective of its applications in commercial radio communication system development has so far received very little attention. This is due to the fact that the atmospheric attenuation of these frequencies are very high and radio links are strictly line-of-sight. Currently, the main problems associated with wireless broadband services are a shortfall in bandwidth and concentration of demand in the center of major cities. It has been suggested that frequencies in the millimeter wave band could be used to ease spectrum congestion problems and provide new services particularly in urban centers [1]. However, to give these ideas substance, it is necessary to investigate the expected severe fading and limitation of channel bandwidth caused by multi path effects in the micro cellular radio environment. The present paper conceives a network of micro cells 100-500 meter in length along sections of road surrounded by tall multi-storied buildings with base station transceivers mounted on lampposts or telegraph poles at height much lower than the height of surrounding buildings.

II. MULTIRAY MODEL

A microcellular urban environment is modeled as rectilinear street configuration surrounded by tall high-rise buildings as shown in figure 1. Based on classical ray theory, a direct ray, ground reflected ray, and the rays undergoing multiple reflections off the building walls are considered as prime contributors to the received signal. The building walls are considered to be made up of cement and concrete, or wooden, or glass structures, assuming a Gaussian distributed surface roughness of building walls in all cases [2]. The rays undergoing multiple reflections off the building walls are considered dominant over corner diffracted and scattered rays. A single specular ground reflection is assumed in all cases. The simulations are carried for N number of reflections, for different micro cell width.

III. RESULTS AND DISCUSSIONS

A set of results for a street 100 m long, at 28 GHz, with transmit beam width 21 degree, is shown in Figure 2. It represents measured received signal profile superimposed on simulation curve, showing close agreement between measured and simulated results. It shows micro variations of the signal with deep fades of the order of 14-19 dB.

A. Distance Power law

It is observed that the slope of the loss curves increases with decrease in the street width from 30 m to 7 m. The similar trends were observed for variation in Side Street width, where the average power drop increases with decrease in street width. This could be attributed to more number of reflections incurred in narrower street as compared to relatively wider streets. When the transmitter position in the main street is changed from 180 m to 60 m, that is nearer to the street intersection, it was found, there is a considerable rise in the average signal power of about 10-15 dB which perhaps is due to reduced path length and less number of reflections in Main Street [3]. In case of relatively narrow streets (width of 7-15 m), the propagation obeys distance power law approximately $r^{-7.5}$. On the contrary, power law is approximately $r^{-5.3}$ in case of wider street (20-30 m).

B. Envelope Fading

The term fast fading refers to the rapid changes in the received signal intensity over short distances due to interference of the waves, incident at the receiver. The local mean is estimated using a moving average routine with a 40λ averaging window and its cumulative distribution is calculated. Figure 3 shows cumulative distribution on a log-normal probability plot. Each data segment is normalized with respect to the local mean to remove the shadow fading. Figure 4 shows a typical normalized plot of fast fading and Figure 5 shows the corresponding cumulative distribution on a Rayleigh probability plot. The variation in loss deviation between different segments is from 0.8 to 8.7 dB with an average of 3.9 dB over 14 sets of results. In case of Parallel Street the received signal fast fading characteristics

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exhibit a significant deviation from the Rayleigh distribution as shown in figure 6.

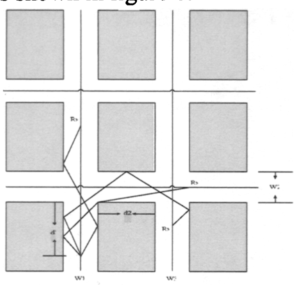

Fig 1 Urban Microcellular street configuration.

IV. CONCLUSION

The presented urban microcellular model gives qualitative as well as quantitative trends of vital propagation characteristics of millimeter wave frequencies. The fast fading behavior shows statistical distribution close to Rayleigh type in Main Street whereas non-Rayleigh type in Side and Parallel Streets This model would hold true only if the height of the base transmitter and receiver is much lower than the height of the surrounding buildings.

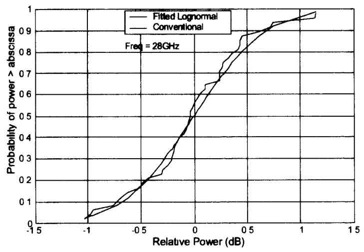

Fig.3 Cumulative distribution of local mean fitted to log-normal distribution for W=15m, f=28 GHz.

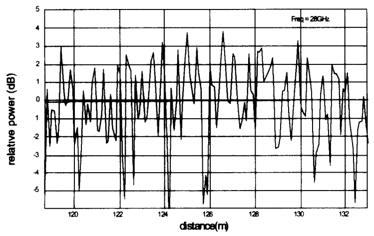

Fig.4 Fast fading envelope in Main street

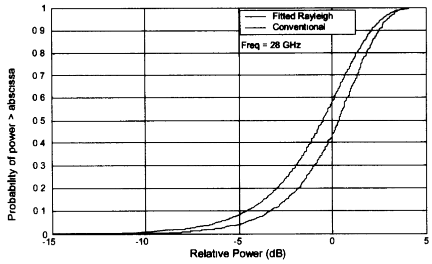

Fig.5 Cumulative distribution of the fast fading of Fig. 8 fitted to Rayleigh distribution

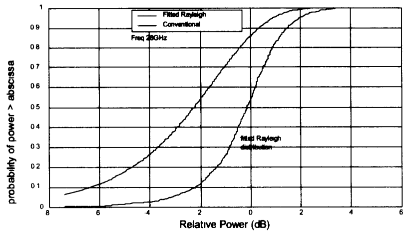

Fig.6 Cumulative distribution of the fast fading in Parallel Street

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