# Foliage Loss Measurements of Tropical Trees at 35 GHz

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***Abstract*** **- The presence of foliage in the propagation channel can lead to severe signal attenuation, and thus the effects of vegetation in the propagation environment need to be considered in any prediction model. In the present work, a measurement study is undertaken to quantify the attenuation caused due to tree canopies, at 35 GHz. The trees prevailing in typical Indian deserts, having variation in the leaf size and leaf density along the tree canopy are included in the study and in each case, attenuation characteristics are reported. The results presented in the paper may be of vital importance for radio cell planning operating at millimeter wave frequency.**

***Index Terms***- **Foliage, Milimeter wave, Tropical tree.**

## I INTRODUCTION

The attenuation of radio signal caused due to the presence of trees obstructing the radio link is termed as foliage loss [1]. Foliage loss is a very complicated issue that has many parameters and variations. At millimeter wavelengths the estimation of foliage caused attenuation is extremely significant for the planning of a radio link [2]. The size of the leaves, branches, and trunks, the density and distribution of leaves, branches and trunks, and the height of the tree relative to the antenna heights are the factors that influence the propagation through vegetation [3-5]. The presence of foliage in the propagation channel can lead to severe signal attenuation, and thus the effects of vegetation in the propagation environment need to be considered in any prediction model. The foliage loss predictions at 900 MHz are reported in [6] for the trees prevailing in the non-tropical regions of the world. The foliage loss modeling at millimeter wave frequencies as suggested by John Scoro *et al* in [7] is a site-specific and not tree specific study and thus cannot be applied to trees prevailing in Indian tropical deserts having different absorption and scattering properties. A measurement study at 35 GHz was therefore, conducted to investigate the effects of various tropical trees. The variety of trees prevailing in typical Indian deserts, having variation in the leaf size and leaf density within the tree canopy are included in the study and in each case, attenuation characteristics are reported.

## II MEASUREMENT SET UP

The experimental system comprises a CW 35 GHz transmitter using 100 mw Gunn source with a transmitting antenna with beam width 14°. The receiving side carries a receiving horn antenna identical to the transmitter, followed by a cavity mixer with 10 mW local oscillator 34 GHz. The 1 GHz IF output of the mixer is fed to a preamplifier followed by a driver amplifier. The amplified output is displayed on a signal analyzer. The transmitter and receiver are kept 12 m apart, with identical height of 2.1 m. Identical tree canopies are prepared for all the trees under investigations, by picking up appropriate number of tree branches and put them in a pot of suitable height. Measurements are carried out for minimum and maximum attenuation.

## III RESULTS

Foliage loss measurements at 35 GHz frequency are carried out for seven different tropical trees; Albizia (Sarais), Ficus Religious (Peepal), Ficus (Bargad), Agle (Beelpatra), Eucaliptus (Safeda), Azadiracta (Neem), and Prosopis (Babool). The measured foliage loss for each of the trees under test are shown in Table. In all cases it is observed that maximum signal loss is observed when the foliage is in proximity of the transmitter, whereas minimum loss is observed nearly at the midpoint of the radio path. The tree of fichus (Bargad) with a maximum of 28.4 dB and minimum of 21.6 dB (as shown in bar graph) offers largest signal absorption leading to the highest average foliage caused loss (nearly 25 dB) among the trees under test. This could be attributed to thick, wide oval shaped leaves and densely distributed branches of fichus. On the other hand, the tree of Prosopis (Babool) offers the lowest foliage loss with a maximum of 12.5 dB and minimum of 10.6 dB, which perhaps due to its smallest sized leaves among all the trees. The empirical relation ship for the foliage caused attenuation is obtained as:

$$L = 0.42\, f^{0.18}\, \Delta d^{0.59}$$

Where, f is the frequency in MHz and $\Delta d$ is the average propagation path length (depth) through a tree in the canopy, in meters.

## IV CONCLUSION

The measurement detail of signal absorption due to foliage of various tropical trees is described. The signal loss when foliage is close to the receiver is 2-3 dB down the value measured at the location close to the transmitter. In all cases, it is observed that maximum signal loss is observed when the foliage is in the proximity of the transmitter, whereas minimum loss is observed nearly at the midpoint of the radio path. This could be attributed to predominance of signal absorption at the terminations whereas diffraction could be the prime propagation mechanism at the midpoint placed

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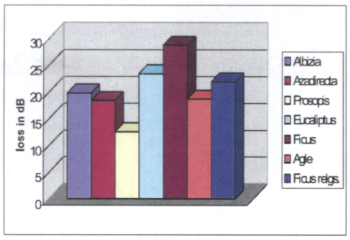


foliage case. The placement of transmitter site close to foliage should be avoided.

**Fig. 1 Average Foliage loss of various tree**

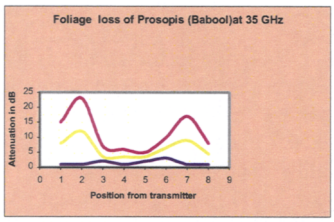


**Fig 2 Foliage loss characteristics of Prosposis**

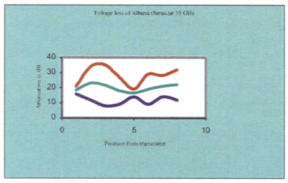


**Fig.3 Foliage loss characteristics of Albizia**

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