RADIO WAVE PROPAGATION STUDIES THROUGH TROPICAL VEGETATION IN MALAYSIA AT VHF

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Abstract

This article present a measurements on radio wave attenuation through tropical vegetation in Malaysia. The frequencies selected were between 30 to 65 MHz with vertical and horizontal polarization. The height of the transmitter and receiver was at 1 and 1.5 meter above the ground respectively and the separation distance varying from 10 to 1000 meter. The measured signal is represented in the form of radio loss and is studied as a function of distance, frequency, polarization and different types of vegetation. The radio loss is also compared with various propagation models.

Introduction

The influence of vegetation environment on radio wave propagation has attracted considerable interest and stimulated a number of measurement program [1,2,5,6,7]. All of the measurements that have been carried out showed that, the transmission loss of the radio signal would occur while propagating in such environment. In Malaysia, most of the terrain are still covered with dense vegetation. A radio wave attenuation would likely to occur due to this environment. Unfortunately, the characteristic of radio signals propagating through tropical vegetation in Malaysia has not yet been conducted in great details.

This paper presents the analysis of measurements on radio signals propagate through three different types of tropical vegetation in Malaysia. In the measurements, the cases considered for attenuation directly through the vegetation where both antenna are located inside the vegetation medium. The total path loss and foliage factor are obtained and it studied as a function of distance, frequency, polarization and 3 different types of vegetation. The results obtained are used to evaluate the existing propagation models for predicting radio wave attenuation propagates through tropical vegetation in Malaysia.

Details of the Measurements

The types of vegetation is represented as Area 1, Area 2 and Area 3. Area 1 is a type tropical bush jungle. The area is mostly covered with dense low level foliage and contain only a few of large trees. The undergrowth is so heavy and is about 2 to 4 meter above the ground. The average tree height is about 6 to 10 meter above the ground and the diameter is about 1.3 meter. Area 2 contains an oil palm field with tall trees and very little low level foliage. The tree is about 4 to 7 meter height above the ground and average tree trunk is about 1.6 meter. The separation distance between each tree is about 10 meter apart. Area 3 is a rubber tree plantation with tall trees and no undergrowth. The average tree height is about 6 to 8 meter and average of the diameter is about 0.8 meter. The foliage of the tree is less compared with the tree located in Area 1 and Area 2. The separation distance between each tree is about 5 meter apart. These area are categorized as a wet evergreen tropical vegetation.

The frequencies selected were between 30 to 65 MHz with vertical and horizontal polarization. The transmitting and receiving antenna height was at 1 and 1.5 meter above the ground respectively and was confined to a maximum separation distance of 1000 meter. The receiving point was located at one location and the transmitting point was moved away at 11 transmitting locations. The measurements were conducted once in each measurement area.

A radio communication transceiver operating at VHF band was used as a transmitting source. A monopole antenna with 3 feet long was used for both polarization. For receiving point, a calibrated field strength meter was used. The measuring receiver is an Anritsu ML524B model which can cover frequency range between 20 to 1000 MHz. The measuring receiver used a dipole antenna and the length of the antenna could be varied according to a particular frequency.

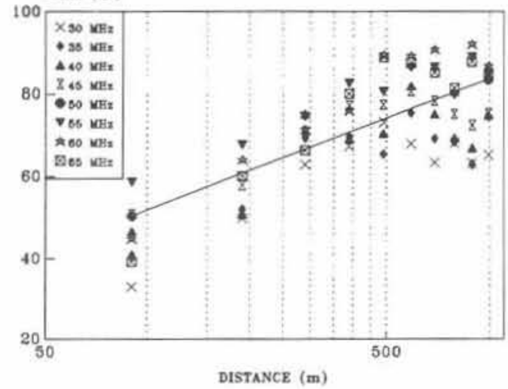

Fig 1: Radio loss dependence on distance in Area 1 (horizontal polarization)

Radio Loss Dependence on Distance, Frequency and Polarization

It is observed that, as the distance increases, the radio loss for vertical and horizontal polarization also increases. For each types of vegetation area, the propagation power law are equal to 3.69, 2.81 and 4.13 for vertical polarization and 3.08, 4.35 and 4.33 for horizontal polarization respectively. In general, the radio loss is found varied about *40 log d* for these 3 different types of vegetation area. These results confirm with most of the models and experimental program that have been conducted [4,6,7]. The example is shown in Figure 1 for vegetation in Area 1 with horizontal polarization.

Generally, it is found that the radio loss is slightly increase with increase in the frequency for both polarization. The small variation of radio loss is probably due to small frequency range (30 to 65 MHz) in the measurements program. The possibility of increases of radio loss with increases in frequency is probably due in term of its wavelength where the vegetation parameter would have larger effect at higher frequency. Since the height of both antennas are located near the ground, therefore the attenuation is greatly depends on these factors. Furthermore, higher depolarization of radio waves at higher frequency would occur especially at vertical polarization due to existence of large vertical component in the vegetation medium. Figure 1 shows the radio loss dependence on frequency for 3 different types of vegetation area. The example is shown at 890 meter with horizontal polarization.

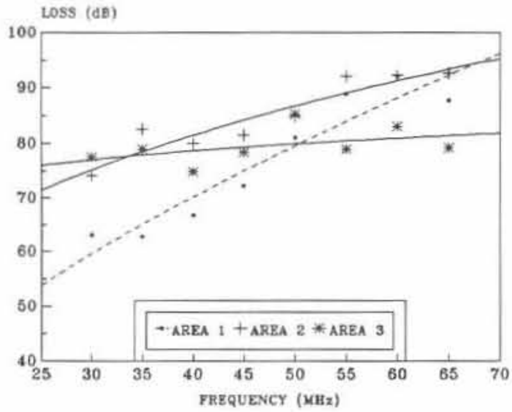

Fig 2: Radio loss dependence on frequency (horizontal polarization)

From the comparison between both polarization, vertical polarization seems to suffer higher attenuation than horizontal polarization. This can be seen by observed the difference between horizontal and vertical polarization at each frequency and particular distance. It is interesting to observe that, this behavior is consistent for each types of vegetation area. Higher attenuation with vertical polarization is probably due to presence of strong vertical component in most of the vegetation area. These results confirm with the measurements that have been conducted [1,5].

Foliage Loss

The quantitive value of radio loss for propagation through the vegetation is defined as the difference between the actual measured path loss in vegetation and expected path loss in absence of vegetation for the same path parameter and set of system [6,7]. This radio loss is defined as 'foliage loss', L_f and is expressed in dB.
Therefore,

$$L_f = L_v - L_s \tag{1}$$

where *Lv* is a radio loss for propagation through the vegetation and *Ls* is a free space loss.

For both polarizations, the *Lf* value is found to increase in distance for distance up to 400 meter. The attenuation is found exponentially attenuated and dependence on distance. This is probably due to contribution of direct and reflected wave through the vegetation medium. The effect of vegetation upon the foliage loss is independent of the horizontal distance at distance beyond 400 meter. The foliage loss is extremely constant or increase at an extremely slow rate as the distance is increase. This is probably due to the transmitted signal propagates by lateral wave mode. This behavior is consistent with each types of vegetation area.

Effect of Different Types of Vegetation

The comparison is made to study the variability of attenuation characteristics for different types of vegetation. For vertical polarization, it is observed that Area 2 has a higher value than Area 1 and Area 3. The possibility of higher attenuation in Area 2 than Area 1 and Area 3 is probably due in term of its wavelength upon the presence of physical tree trunk and undergrowth. In Area 1, the presence of large vertical tree trunk is less compared with Area 2 and Area 3. The transmitted signal would have to pass through a larger vegetation parameter in Area 2 and Area 3 and experience much attenuation. The case is different in Area 1 where the transmitted signal would pass through the vegetation parameter without undergoing a larger attenuation. For horizontal polarization, no dependence on foliage loss have been observed for these 3 different types of vegetation. This is probably due to none existence of strong horizontal component in the vegetation medium since both antennas are located at lower antenna height.

Specific Attenuation

The rate of specific attenuation, α is obtained by dividing the foliage loss (*Lf*) by the thickness of the forest slab through which the transmission is taking place, and is expressed in dB/m.
Therefore

$$\alpha = \frac{L_f\ (dB/m)}{d\ (m)} \tag{2}$$

where *d* is the horizontal distance of the vegetation slab.

For both polarization, a relatively large variation of α are noticed for distance less than 400 m and small variation of α for distance beyond 400 m. In case of distance less than 400 m, the specific attenuation, α from the measured data were found exponentially attenuated and dependent on distance. For distance beyond 400 m, the specific attenuation, α becomes approximately constant or increases at an extremely slow rate as the distance is increases. The characteristic of specific attenuation is consistent with different types of vegetation area. This characteristic of α supports the contribution of through the vegetation and lateral wave modes of propagation and confirm with the experimental results that have been conducted [4,6,7].

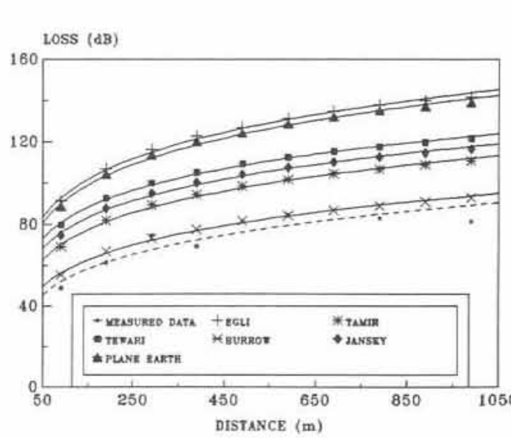

Fig 3: Comparison between propagation models with radio loss at 55 MHz in Area 1 (vertical polarization)

Comparison Between the Propagation Model

For predicting the coverage area between two communication points in the vegetated terrain, the path loss between these two points are predicted by using the available propagation models. These models are Burrow [2], plane earth modified by a foliage factor, Tamir & Dence [4], Tewari & Swarup [6], Egli [6,7], and Jansky & Bailey [7]. In the analysis, the radio loss is plotted against distance and frequency. The evaluation is made to determine the difference between each propagation models with measured radio loss and analyzed which model that has the least error. The example is shown in Figure 2 at 55 MHz for vegetation in Area 1.

The radio loss against the distance has been made to provide the variability of the radio loss against the propose propagation models. From the curve, the radio loss is found to closely follow Burrow and Tamir & Dence models. In general, it was found that, the measured radio loss is to closely follow Burrow model for these 3 different types of vegetation area. From the comparison between these propagation models and radio loss in term of frequency, it is interesting to observe that, for all of the measurements in the vegetated area, the radio loss is to found closely follow Burrow model. This phenomena suggested that, Burrow model is the most appropriate and suitable model to be used for prediction the radio loss propagates through tropical vegetation in Malaysia.

Conclusions

The physical parameter and characteristic of the vegetation are found strongly influence the attenuation factor. The variation in the physical characteristic of the vegetation constitute different attenuation factor. The results also showed that, propagation loss are lower for horizontal polarization than vertical polarization. The results indicate that, horizontal polarization is more favorable rather than vertical polarization. Therefore, the use of horizontal polarization give some advantage while communicating through the vegetation environment.

The results of the propagation measurements strongly supported the existing theories for propagation inside the vegetation environment. This result suggested the principle mode of propagation along the air-tree top boundary (lateral wave) and direct and reflected wave mode (through the vegetation). For predicting the radio loss, the measured radio loss from the result of measurements incorporate most with Burrow model. This model is suggested as the most appropriate model for prediction of the coverage area for VHF communication system in tropical region.

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Acknowledgements

We would like to acknowledge with thanks for the helpful assistance given by the following member of staff of Universiti Teknologi Malaysia during the experimental program : Dr K Norazan, Mr A S Roslan and Mr A Nasir.