# Generation of an Empiric Propagation Model for Forest Environment at GSM900/GSM1800/CDMA2100


Murat BITIRGAN[1,2], Yunus Emre YORUK[1,2], Sami CELIK[1,2], Osman KURNAZ[2]

Selcuk HELHEL[2,3] and Sukru OZEN[2,3]

[1] Turkcell Iletisim Hizmetleri A.S., Antalya, TURKEY

murat.bitirgan@turkcell.com.tr, sami.celik@turkcell.com.tr, yunus.yoruk@turkcell.com.tr

[2]Akdeniz University, Engineering Faculty, Electrical–Electronics Engineering, 07058 Antalya, TURKEY

okurnaz@akdeniz.edu.tr, selcukhelhel@akdeniz.edu.tr, sukruozen@akdeniz.edu.tr

[3]Akdeniz University, Industrial and Medical Application Based Microwave Research Center, Antalya, TURKEY



## Abstract

This paper presents how to obtain an empiric propagation model in forest area by using both reference open area and field measurements. Empiric models for GSM 900, GSM 1800 and CDMA 2100 have been plotted through the number of tree passed in the forested area. While results conclude that path loss both in theory and measurements are increasing with respect to frequency, an obtained empiric formula for CDMA2100 is better good track in measurements than the others.


## 1. Introduction

Mobile communication is widespread all over the world, day by day. So, planning and optimization of mobile networks are important for coverage and quality. Planning tools which have been using propagation path loss models are generally based on building areas. Radio propagation through forested area, effects of trees and weather conditions on radio propagation [1] are important as well as other environments. Weissberger [2], ITU-R [3] and COST235 [4] are the well-known empirical models and these methodologies focus on the radio-wave propagation through the foliage medium. Also, analytical methods proposed good prediction accuracy, they are complicated and require great computational resources [5].

A measurement setup mostly chosen by GSM operators was used. It is simulating base station transmitter units including certain frequency and certain modulation techniques in mobile communication. Nemo-Handy software loaded mobile phone was used as a receiver. Most commonly used technologies in the world GSM900, GSM1800 and CDMA2100 have been studied.

## 2. Mathematical Background and Methodology

Friis propagation model is a starting point for any propagation model generation. An obstruction loss factor L added Friis equation [5] is given by

$$\frac{P_r}{P_t} = \frac{G_t G_r \lambda^2}{(4\pi d)^2 L} \qquad (1)$$

where $P_r$, $P_t$, $G_t$, $G_r$, d, $\lambda$ and L are received power, transmitting power, transmitting antenna gain, receiving antenna gain, distance, wavelength and obstruction loss factor, respectively. Path loss equation can then be written as in Eq.2

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$$PL(dB) = 10\log(G_t G_r) + 20\log\lambda - 20\log(4\pi d) - 10\log L \qquad (2)$$

In order to obtain an empiric propagation formula for a certain environment, one may calculate the factor by using both environment and reference open area measurements, and the factor L can easily be obtained by using Eq.3

$$PL_{forest} = PL_{open} + L \qquad (3)$$

where $PL_{forest}$ is the forested area power level measurement, $PL_{open}$ is an open area power level measurement and L is forest area loss factor related to trees.

## 3. Test Setup and Test Environment

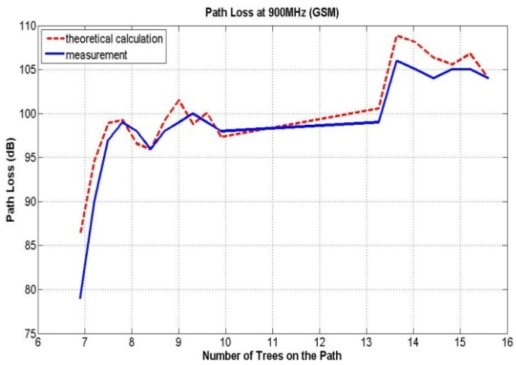
The transmitter (brand name is Andrew) holding a CELLMAX-O-25 omni-directional antenna operating between 806MHz - 2100MHz was used as a measurement setup. Certain frequencies at GSM900, GSM1800 and CDMA2100 were selected. Transmitting and receiving antennas were located at 2 m height, and output power was set to 21dBm. Nemo loaded Nokia N95 mobile phone was used as a radio receiver as well as GPS receiver.

The measurements have been conducted in typical pine tree forest. The typical pine trees in the area have an average height of 5 m and the main trunk diameter is about 25 cm. The trees are nearly equally spaced with a separation of 3 m. The leaves of pine trees form a dense canopy. The environment and weather condition was not wet.

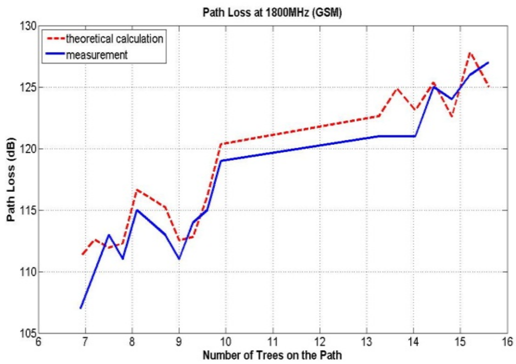

Figure1. *Test Transmitter and Test Environment*

## 4. Results

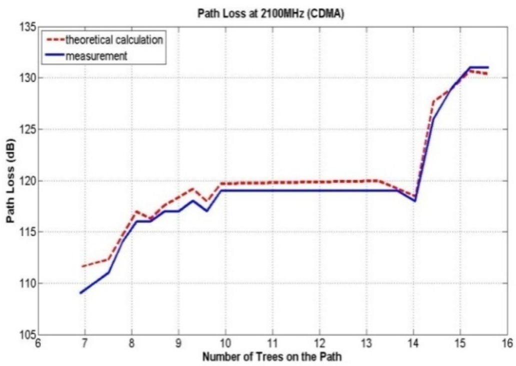
Results indicate that theory and measurements are good in track of each other. Maximum deviation has been obtained at 1800MHz, and minimum deviation has been obtained at CDMA2100. Figure2a, 2b and 2c show the plots of proposed model and measurements at GSM900, GSM1800 and CDMA2100, respectively. Figure 2d shows deviation between path loss model and path loss measurements in comparison. A deviation is about 1dB at CDMA2100, 2dB at 900MHz and 4dB at 1800MHz.



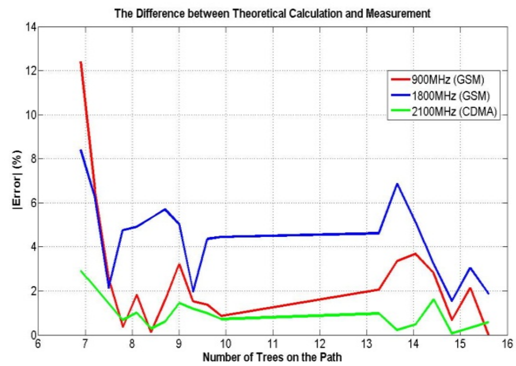

(a) *900 MHz (GSM) in forest area*




(b) *1800 MHz (GSM) in forest area*




(c*) 2100 MHz (CDMA) in forest area*




(d) *Theory and Measurement Difference*

Figure2. *Theoretical and Measurement Path Loss*

The success of the proposed model is shown in Table1. Mean error is the least for CDMA2100 and the most for GSM1800. It should be noted that first measurement data is not taken into account in mean error and standard deviation calculation since the error margin for the first data is rather high. It could be a result of measurement error.

Table1. Mean error and standard deviation between proposed model and measurement

| Modulation / Frequency Band | Mean Relative Error (%) | Standard Deviation |
|---|---|---|
| GSM 900 | 2.0423 | 1.6325 |
| GSM 1800 | 4.1844 | 1.6164 |
| CDMA 2100 | 0.8651 | 0.5653 |

## 5. Conclusion

This paper presents that an empiric propagation model for a certain environment can easily be obtained by using both certain environment measurements and open area measurements. Model error in this approach increasing from 900MHz to 1800MHz, but it decreased at CDMA2100. This could be a result of different technology with 5 MHz bandwidth of CDMA-2100.

## 6. Acknowledgement

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