

Validation and Comparative Study of Measured and Predicted Pathloss of Some GSM Networks in Sub-Urban Area

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Abstract

This research work presents gsm pathloss through Kwara State Polytechnic permanent site, Ilorin. The study area is between latitudes $08^{\circ} 32' 37.6''$ and $08^{\circ} 34' 27.9''$, longitudes $04^{\circ} 38' 07.7''$ and $04^{\circ} 38' 17.3''$. The elevations of the two reference points were 350 and 364 meters respectively. The signal strength of MTN, GLO, AIRTEL and ETISALAT networks were measured with TECNO D3 Android mobile receiver from Base Transceiver Station (BTS) at intervals of 100 meters. The linear distance covered from the array of cell site was 3,100 meters. The signal strength data obtained were used with appropriate equation to determine the pathloss in the study area. The pathlosses obtained were compared with the pathloss computed from COST-231 HATA and LEAST SQUARE MODELS for suburban area where the measurements were taken. The results proved that the predicted and the measured pathloss were intertwined and close to each other and the values obtained shows that the people living around the study area are suffering from poor gsm communication system. This paper is recommended for radio engineers and gsm telecommunication companies for effective planning.

Keywords: Gsm, Pathloss, COST-231 HATA, LEAST SQUARE MODELS

1.0 Introduction

In wireless communication system, the losses that occurred between transmitter and receiver are known as propagation pathloss. Pathloss plays very important role at Network planning level. Pathloss (or path attenuation) is an unwanted introduction of energy tending to interfere with the proper reception and reproduction of the signals during its journey from transmitter to receiver. It reduces power density (attenuation) of an electromagnetic wave as it propagates through space. Radio wave signal pathloss is an important one in the analysis and design of a radio communication system [1, 2]. The signal pathloss generally determines many parameters of the radio communications system like transmitter power, and the antennas, especially their gain, height and general location. The pathloss also affects other parameters such as necessary receiver sensitivity, the form of transmission used and many other factors. Due to this, it is essential to realize the reasons for radio pathloss, and to determine the levels of the signal loss for a given radio path [3]. The pathloss is repeatedly mathematically and these calculations are repeatedly undertaken to prepare the coverage or system design activities [4]. Therefore, Pathloss calculations are used in many radio and wireless survey tools to determine signal strength at different locations. This type of wireless survey tools are used to help determine the radio signal strengths before installing the equipment. The installation of macro cell base station is very high, so, before installation, radio coverage surveys are important. At present generation the wired network systems are replaced by the wireless network systems. The main difference between the two is the change from a fixed network location to mobile network location, i.e. an address is no longer a physical location and an address will reach the wireless station. This reason is to justify the prospective additional wireless network Quality of Service (QoS) techniques. The Quality of Service itself explains the performance of any responsible system [5]. In wireless communication, the average received power decreases logarithmically with distance. The main factor responsible for this is pathloss, which represents signal attenuation as a positive quantity measured in dB.

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Quality of Service (QoS) is the measure which defines the performance in any accountable system[6]. The criteria taken into account by the user to justify a service vary according to the nature of the considered service. It involves simple concepts such as service availability, transmission characteristics and subjective estimates. Handover is the key operation in cellular mobile communication systems, which is accomplished by the system and is imperceptible for the user. This paper attempts to measure the signal strength and pathloss of some GSM networks (MTN, AIRTEL, GLO and ETISALAT) in Kwara State Polytechnic permanent site to Ara village with the view to address the complaint of GSM subscribers. The paper shall also compare the closeness of the measured and predicted pathloss and validate the relevance of the twopredicted models used for the aforementioned area.

2.0 Methodology

Two reference locations were picked within the study area with Global Positioning System. The first location was at the gate of Kwara State Polytechnic permanent site at latitude $08^{\circ} 32' 37.6''$, longitude $04^{\circ} 38' 07.7''$ and Ara village at latitude $08^{\circ} 34' 27.9''$, longitude $04^{\circ} 38' 17.3''$ with elevation of 350 and 364 meters respectively. The gate of Kwara State Polytechnic permanent site that was picked as the first location consists of arrays of cell sites. The signal strength of MTN, GLO, AIRTEL and ETISALAT networks were measured with TECNO D3 Android mobile receiver from Base Transceiver Station (BTS) at intervals of 100 meters. The linear distance covered from the array of cell site was 3,100 meters. The signal strength of each of the GSM communication networks under study was computed with appropriate equation to determine the pathloss in the study area. The pathlosses measured were compared with the computed pathloss from some of the existing models for suburban area where the measurements were taken.

The equation used to practically determine the pathloss [7] is given as

$$L_p = EIRP - P_R \quad (1)$$

Where L_p = Pathloss

EIRP = Effective Isotropic Radiated Power 47db

P_R = Received Power

Cost-231 Hata Model

A model that is widely used for predicting pathloss in mobile wireless system is the COST-231 Hata model[8]. The COST-231 Hata model is designed to be used in the frequency band from 900MHz to 1800MHz. It also contains corrections for urban, suburban and rural (flat) environments. The basic equation for pathloss in dB

$$L = 46.3 + 33.9 \log f - 13.82 \log h_B - a(h_R) + (44.9 - 6.55 \log h_B) \log d \quad (2)$$

Where,

L = Median Pathloss in Decibel

f = Frequency of Transmission in MHz (900-1800)

h_B = Base Station Antenna Effective Height (34m)

d = Distance in Kilo meter

h_R = Mobile Station Antenna Height Correction Factor as describe in the Hata model for urban areas. But we consider for suburban area and rural areas

$$a(h_R) = (1.1 \log f - 0.7)h_R - 1.56 \log f - 0.8 \quad (3)$$

Least Square Model

The Least Square model pathloss formula with correction factors [9] is given as:

$$LS = 98.92 + 14.65d - 0.25d^2 \quad (4)$$

Where, the parameter LS is Least Square model

d is the distance in kilometer (km).

3.0 Results and Discussion

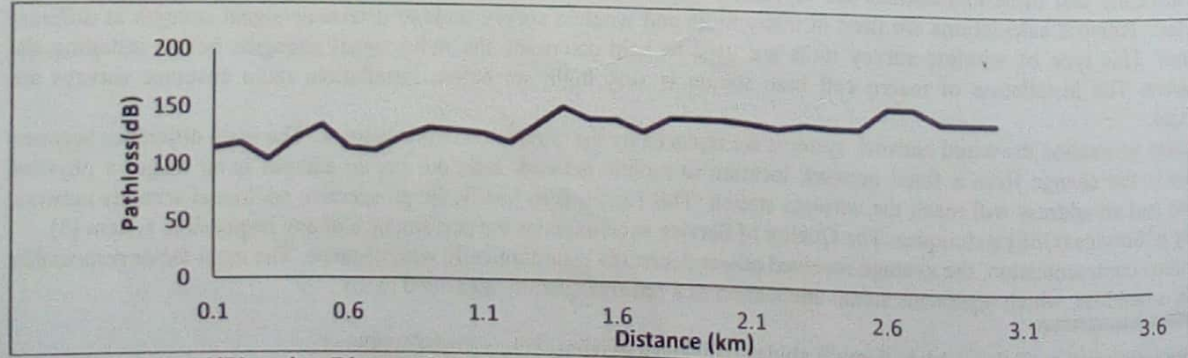


Figure 1: Pathloss (dB) against Distance (km) for ETISALAT network.

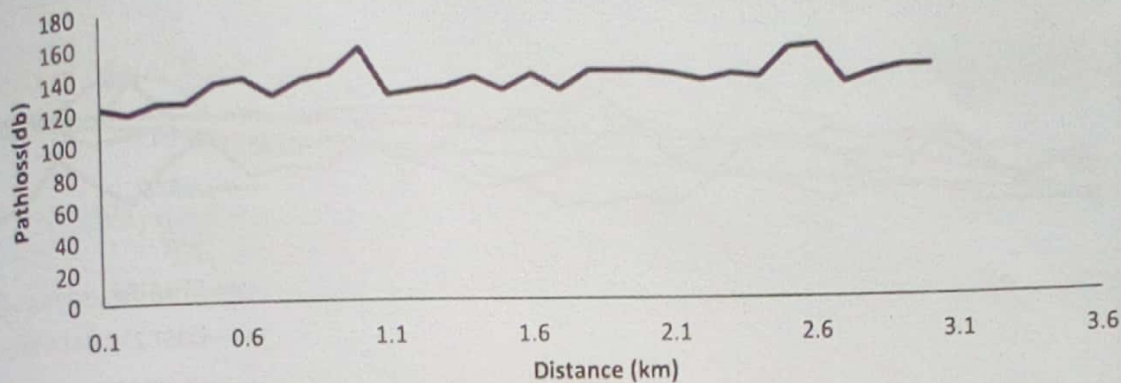


Figure 2: Pathloss (dB) against Distance (km) for GLO network

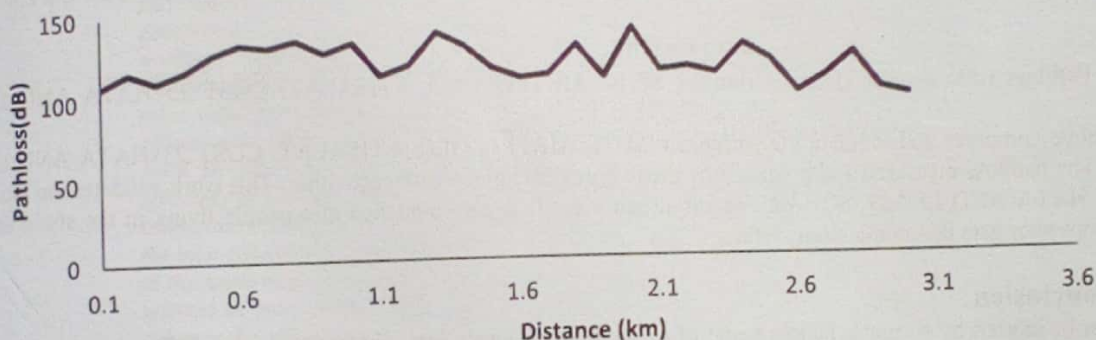


Figure 3: Pathloss (dB) against Distance (km) for MTN network

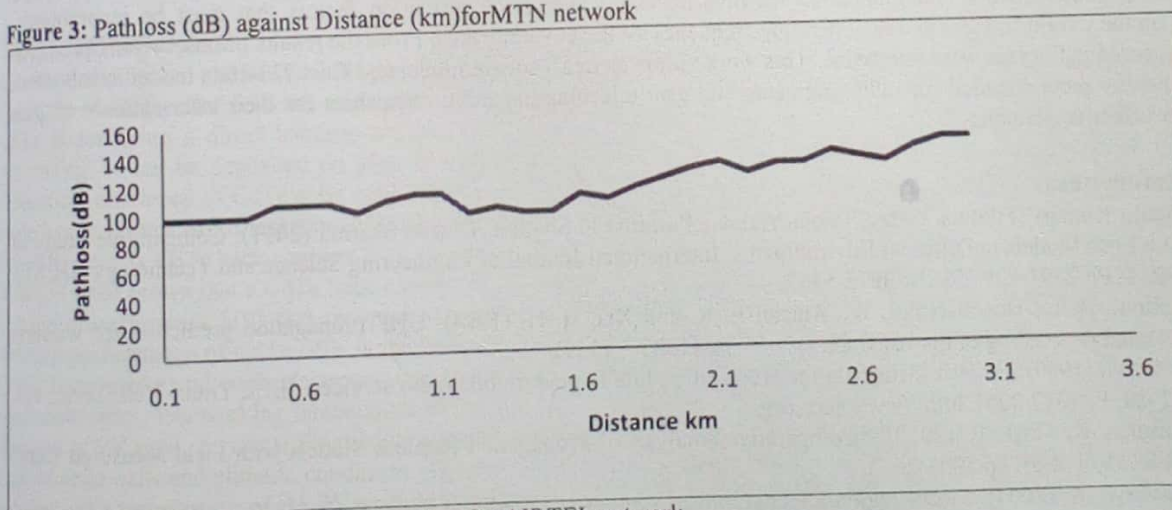


Figure 4: Pathloss (dB) against Distance (km) for AIRTEL network

Figures 1 to 4 are plots of pathloss against the distance (km) for each of the GSM networks under considerations. The fluctuations in the pathloss measured were as a result of atmospheric ducting, ionospheric reflection and refraction and reflections from terrestrial objects such as mountains and high buildings. The values of pathloss measured in the study area for each network were too high for effective optimum communication system. The pathloss measured as shown in figure 1 for ETISALAT network ranges between 104 to 158 dB. The pathloss measured for GLO network was between 118 to 160 dB (Figure 2). For MTN network, the pathloss measured was between 108 to 140 dB (Figure 3). The pathloss measured for AIRTEL 98 to 144 dB (Figure 4) seems to be fair in comparisons with pathloss measured by other networks under study. Apart from atmospheric ducting, ionospheric reflections and refractions, and reflections from terrestrial objects such as high mountains and buildings, another cause of fluctuations in the signal strength is the periodic pulses from base stations. The measured pathloss in the study area is an indication that people in the area are suffering with either call drop or call termination or poor audible quality in their GSM communications system.

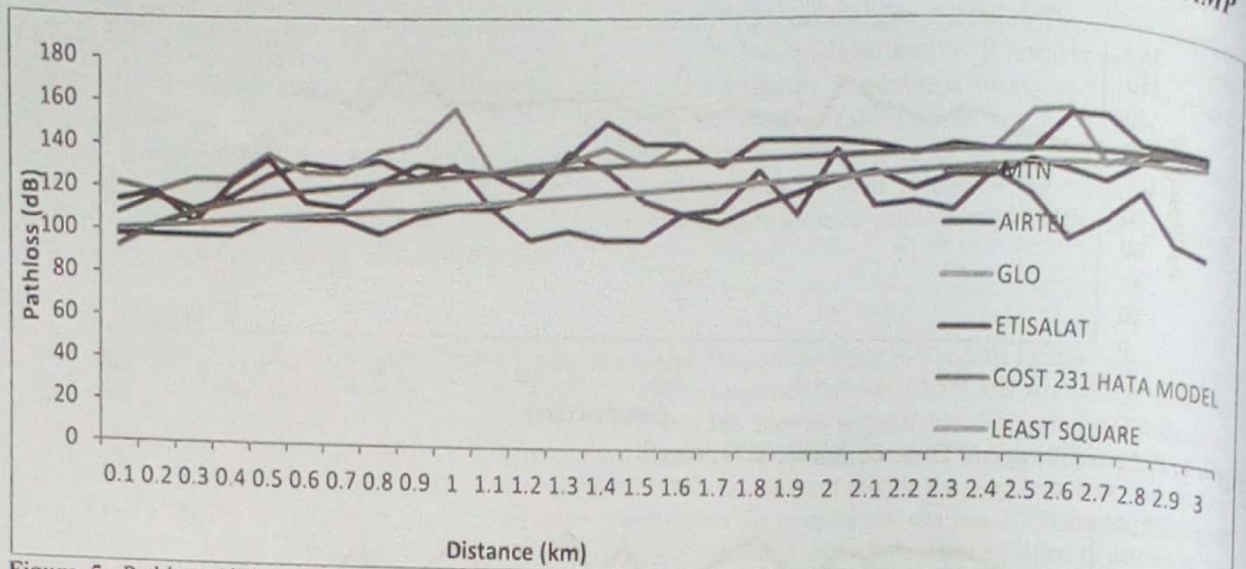


Figure 5: Pathloss (dB) against Distance (km) for MTN, AIRTEL, GLO, ETISALAT, COST 231 HATA AND LEAST SQUARE.

Figure 5 above compares and validate the pathloss of MTN, AIRTEL, GLO, ETISALAT, COST 231 HATA AND LEAST SQUARE. The pathloss measured and predicted by the two models agrees with each other. This work validates the models of COST 231 HATA AND LEAST SQUARE in sub-urban area. It is also evidence that people living in the study area are suffering from poor gsm communication system.

4.0 Conclusion

Pathloss can be caused by so many factors some of which are free space loss, absorption losses, diffraction, multipath, and atmosphere. A good network communication requires necessary empirical correction factors that must be incorporated, depending on the terrain features and the operating frequency of the coverage area. From the results of observation, predicted and the measured pathlosses were intertwined. This work validates Least square model and Cost 231-Hata model in sub-urban areas and hereby recommended for radio engineers and gsm telecommunication companies for their information's on gsm pathloss for effective planning.

5.0 References

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