American Journal of Engineering Research (AJER)
e-ISSN : 2320-0847 p-ISSN : 2320-0936
Volume-03, Issue-01, pp-272-279
www.ajer.org

Research Paper Open Access

Impact of Transmission Distance on the Strength of Received Signals within the Vicinity of Four Base Stations

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Abstract: **-**Signal propagation is an essential part of communication system. The achievement of a complete communication system involves the source where the signal is been generated from, the medium and the destination. This research work concentrated on radio broadcasting stations where the source of reference is mainly the radiating antenna, free space as channel and receivers as the destination. The broadcast signal strength measurements were carried out around radiating antennas for four different radio broadcasting stations situated in different locations. It was therefore established that the radio broadcast signal strength decreases as the line-of-sight distance increases except along a transmission path where metal-poles were found.

Keywords**:** **-***Radio, Signal Strength, Line-of-Sight.*

I. INTRODUCTION

An observation was made that clear radio signals were not regularly received and as such this paper was borne out of the inquisitiveness to know what was responsible for this and to be able to determine how distance (nature of path inclusive) can affect the signals received. Eric Cheng-Chung L.O. (2007) [1] reported: Electronic communication is the currency of our time, which lies on communicating information at certain rate between geographically separated locations reliably. Figure 1 shows the process taking to transmit and receive a message electronically.

Figure1: Communication Process [1]

Also, the ionospheric radio propagation has a strong connection to space weather. A sudden ionospheres' disturbance or shortwave fadeout is observed when the x-rays associated with a solar flare ionize the ionosphere D-region. Enhanced ionization in that region increases the absorption of radio signals passing through it. Whenever we experience the strongest solar flares, complete absorption of virtually all ionospherically propagated radio signals in the sunlight hemisphere can occur. These solar flares can distrupt HF radio propagation and affect the GPS accuracy [2]. Since radio propagation is not 100% predictive, services such as the emergency locator transmitters in flight communication with ocean crossing aircraft as well as some television broadcasting have been moved to communication satellites because a satellite link though expensive can offer highly predictable and stable line of sight coverage of a given area.
The inverse square law is a principle that describes the way radiant energy propagates through space and it states that the power intensity per unit area from a point source, if the rays strike the surface at a right angle, varies inversely according to the distance from the source.

II. PATH LOSS MODEL

A transmission via a radio channel will be affected by path loss (average signalpower attenuation), which is largely depending on the distance between thetransmitting and receiving radio antennas. Further, characteristics of objectsin the radio channel, particularly in the vicinity of the receiving MS, such asterrain, buildings and vegetation may also have a significant impact on thepath loss.

The prediction of the expected mean value of the received signal power,PRx, is crucial in the planning-phase of a cellular mobile radio network. Theknowledge of the expected coverage area for each base station in a cellular network isvery important in order to estimate the minimum acceptable reuse distanceof the carrier frequencies [3]. In CDMA radio access systems, such as IS-95,the BS coverage area will dictate the PN sequence reuse scheme that has tobe put in place [3].In a simple propagation model, the mean path loss is proportional to thedistance, d, to the power of the path loss exponent, γ, as$L \propto d$ (1)where γ indicates the rate at which the path loss increases with distance. Inthe logarithmic domain, this relationship may be expressed as:

$$L[dB] = A + B \gamma \log10(d) \quad (2)$$

where the terms A and B are variables that depend on multiple parameters,as will be shown in later sections. The variable γ depends on terrain andtopographical features and may take on values from 2 (free space) up to 6for strong attenuation. For guided wave phenomenon, which may occur intunnels, street canyons, or corridors inside buildings, even values below 2 arepossible. Some of the models developed over the years are: Okumura Model, COST231-Hata model, Egli Model, Friis Model etc [4-10].

III. RESEARCH METHODOLOGY

The general survey and physical planning of the propagation environment was done first. This was to ensure that the best routes for the research were taken in order to ensure that the environmental factors (both natural and manmade) to be considered for all the stations are not totally the same. The battery of the GPS and the field strength meter were charged. GPS 72 Germin (Plate 1) was used to determine the elevation, longitude and the latitude of the locations where measurements were taken. This was also used to measure the Line Of Sight (LOS) distance (in meters) from the transmitting antenna. In situations where 150m distance could not be obtained before a major obstacle, the distance from the base of the transmitting antenna to the obstacle was first taken and added to the width of the obstacle measured at its end. The total was recorded as obstacle distance and the new point after the obstacle was taken as the reference point (Fig. 2). At approximately 10m separating distance, the signal strength measurementwas taken in dBµ using a BC1173 DBC field strength meter of 50 ohm (Plate 2) at different observation point (Fig. 3). Data comparism was done by plotting the graph of signal strength against distance for each station. This is as summarized in figure 2.

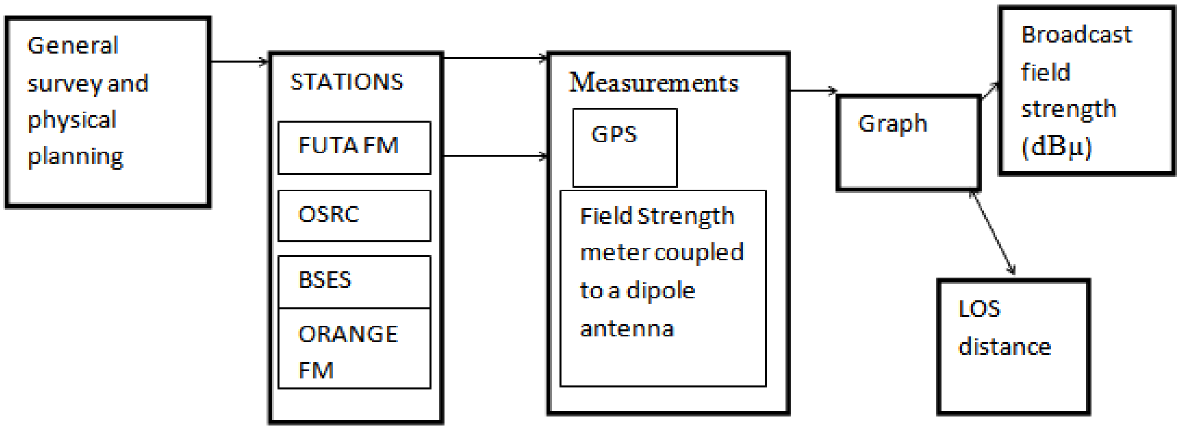

Figure 2: Research Performance matrices

Plate 1: Field Strength Meter Plate 2: GPS

The propagation measurement environment of this study was performed within 150m line of sight distance from the reference point by considering only one path for each base station. The FM stations considered are:

- Ondo State Radio vision Corporation (OSRC) 96.5MHz
- Broadcasting Service of Ekiti State (BSES) 91.5MHz
- FUTA Radio Station 93.1MHz
- Orange Radio Station 94.5MHz

Figure 3: Observation Point

IV. RESULTS AND DISCUSSION

Table 1: Measurement taken at OSRC from the Reference point to a Distance of 150m

LOS DISTANCE (m)	Nº	Eº	ELEVATION (m)	ACCURACY (m)	AVERAGE SIGNAL STRENGHT READING (dBµV)
0.00	07.30345	005.16122	395.2	14.5	82.4
10.13	07.30353	005.16114	395.6	18.0	81.65
20.08	07.30340	005.16164	394.4	16.6	80.01
30.14	07.30293	005.16098	397.1	9.9	78.85
40.19	07.30285	005.16096	393.5	8.5	76.89
50.01	07.30273	005.16091	396.5	9.4	75.84
60.14	07.30266	005.16089	392.1	8.8	74.86
70.00	07.30259	005.16084	394.8	8.3	73.87
80.16	07.30249	005.16082	392.6	9.3	71.06
90.10	07.30240	005.16078	393.1	9.9	70.63
100.09	07.30233	005.16074	394.1	8.1	69.21
110.32	07.30223	005.16071	394.2	7.1	68.82
120.14	07.30215	005.16067	391.3	8.1	67.58
130.33	07.30208	005.16062	389.7	9.9	66.84
140.06	07.30198	005.16060	390.8	8.1	65.99
150.03	07.30188	005.16055	392.1	8.3	64.86

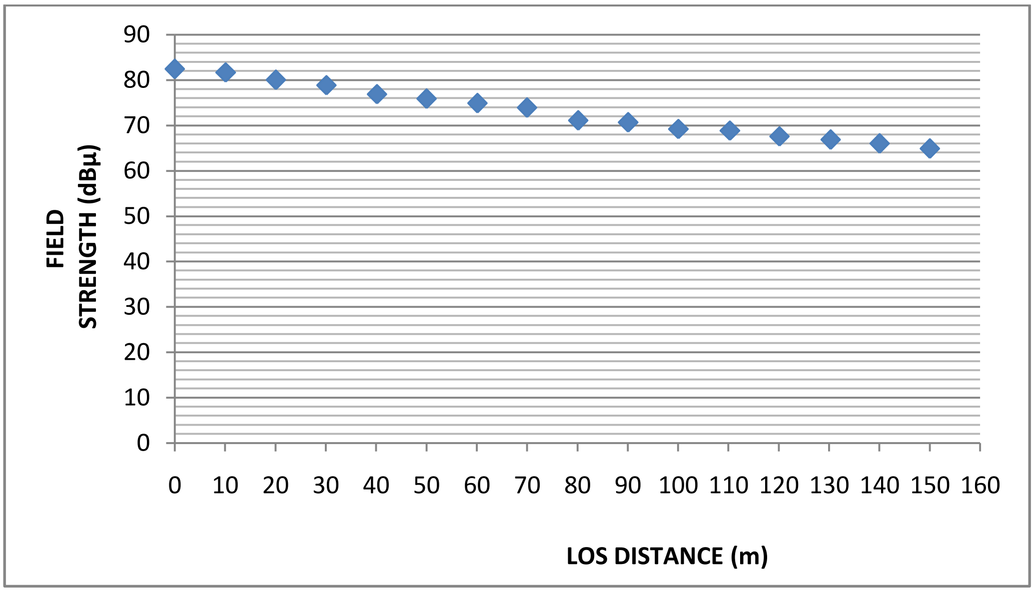

Figure 4: Propagation Profile of OSRC Radio Station (96.5 FM)

Table 1 shows the results of measurements taken with OSRC Radio Station where Fig. 4 shows the relationship between signal field strength. It could be observed that the field strength decreases with increasing distance from the reference point and also from the base station. This obeys "inverse square law" of radio wave propagation. But at certain points, the attenuation was not much; this could be as a result of the short range of distance considered.

Table 2: Measurement taken at BSES from the reference point to a distance of 150m

LOS DISTANCE (m)	N°	E°	ELEVATION (m)	ACCURACY (m)	AVERAGE SIGNAL STRENGHT READING (dBµV)
0.00	07.67551	005.24690	383.7	9.4	82.3
10.06	07.67553	005.24678	388.9	9.0	79.73
20.15	07.67555	005.24670	388.0	7.2	79.03
30.04	07.67558	005.24661	388.7	8.1	76.87
40.09	07.67562	005.24651	387.3	8.2	70.07
50.10	07.67564	005.24643	391.9	8.9	69.26
60.24	07.67566	005.24634	390.9	8.5	68.84
70.06	07.67570	005.24626	392.6	7.4	66.87
80.18	07.67575	005.24614	399.7	7.8	65.48
90.61	07.67577	005.24605	396.3	8.6	63.78
100.49	07.67578	005.24597	391.9	8.2	61.98
110.72	07.67581	005.24588	395.5	9.1	60.03
120.26	07.67585	005.24581	396.9	7.8	58.45
130.06	07.67587	005.24572	393.0	8.0	56.84
140.22	07.67591	005.24565	394.5	7.0	54.19
150.48	07.67594	005.24557	394.3	9.2	52.83

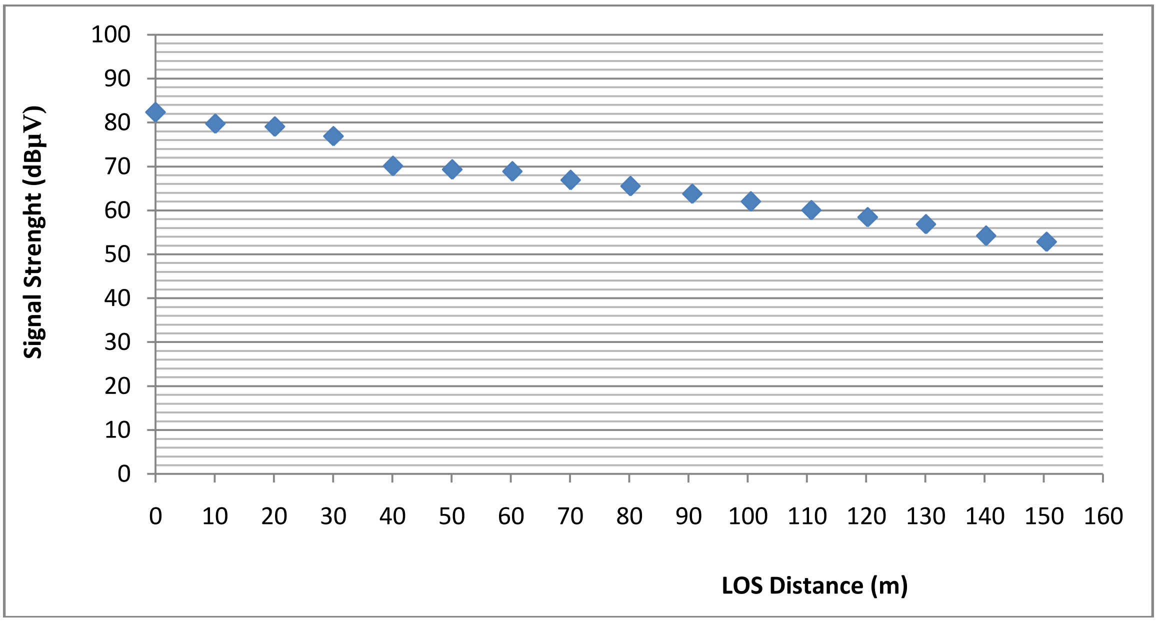

Figure 5: Propagation profile of BSES Radio Station (91.5 FM)

Table 2 shows the results obtained at the BSES Radio Station and Fig. 5 shows the relationship that exists between the two measured parameters. It could be observed that, signal strength decreases as the line-of-sight distance increases. It also obeys the "inverse square law".

Table 3: Measurement taken at ORANGE FM from the reference point to a distance of 150m

LOS DISTANCE (m)	N°	E°	ELEVATION (m)	ACCURACY (m)	SIGNAL STRENGHT AVERAGE READING(dBµV)
0.00	07.28979	005.19405	378.1	11.0	94.4
10.07	07.28976	005.19395	379.6	9.5	93.85
20.07	07.28990	005.19398	378.9	8.2	92.08
30.05	07.28996	005.19381	378.9	9.1	91.65
40.35	07.29002	005.19375	377.0	10.1	90.43
50.26	07.29008	005.19361	379.6	14.3	88.87
60.01	07.29014	005.19355	380.3	10.4	87.59
70.07	07.29019	005.19349	380.0	8.9	85.84
80.06	07.29025	005.19342	381.7	10.2	84.01
90.13	07.29030	005.19332	383.5	8.3	82.75
100.08	07.29033	005.19325	381.8	8.7	80.89
110.26	07.29032	005.19313	384.2	8.7	78.54
120.04	07.29034	005.19307	382.0	8.9	76.68
130.25	07.29037	005.19297	381.3	8.7	74.87
140.06	07.29038	005.19287	381.2	9.0	72.54
150.12	07.29040	005.19275	385.1	10.2	70.34

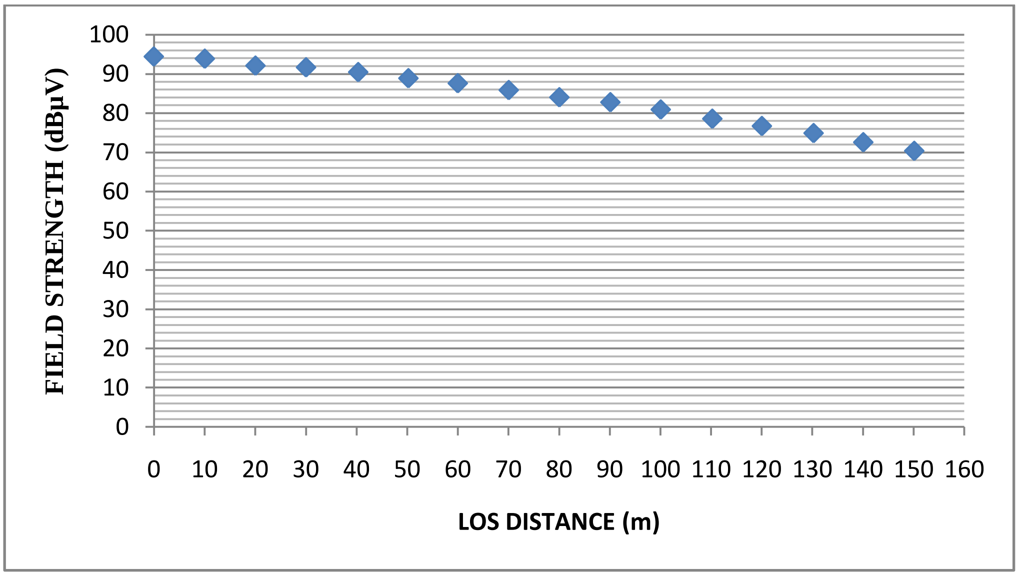

Figure 6: Propagation Profile of Orange Radio Station (94.5 FM)

Table 3 shows the results obtained with Orange Radio Station and Fig. 6 shows the relationship that exist between measured signal strength and line-of-sight distance. It could be observed that, signal strength decreases as the line-of-sight distance increases. It also obeys the "inverse square law" which states that the signal field strength is inversely proportional to the square of the line-of-sight distance.

Table 4: Measurement taken at FUTA Radio from the reference point (antenna base) to a distance of 150m

LOS DISTANCE (m)	N°	E°	ELEVATION (m)	ACCURACY (m)	SIGNAL STRENGHT AVERAGE READING (dBµV)
0.00	07.30240	005.13887	391.5	16.6	90.64
10.16	07.30235	005.13876	392.0	10.3	86.73
20.57	07.30224	005.13874	389.9	7.9	85.7
30.03	07.30217	005.13871	383.7	8.9	83.89
40.07	07.30202	005.13870	387.8	10.2	80.21
50.04	07.30195	005.13868	390.5	8.0	84.06
60.11	07.30180	005.13867	388.3	10.0	84.01
70.22	07.30172	005.13863	390.7	8.7	85.52
80.17	07.30177	005.13860	389.9	11.3	71.83
90.08	07.30168	005.13858	391.1	7.3	69.94
100.12	07.30159	005.13859	387.8	9.7	67.57
110.19	07.30145	005.13858	389.0	9.4	65.72
120.07	07.30136	005.13855	390.2	10.4	64.03
130.10	07.30126	005.13854	389.5	9.6	62.68
140.04	07.30120	005.13853	390.2	10.5	60.55
150.06	07.30109	005.13852	387.3	9.5	59.87

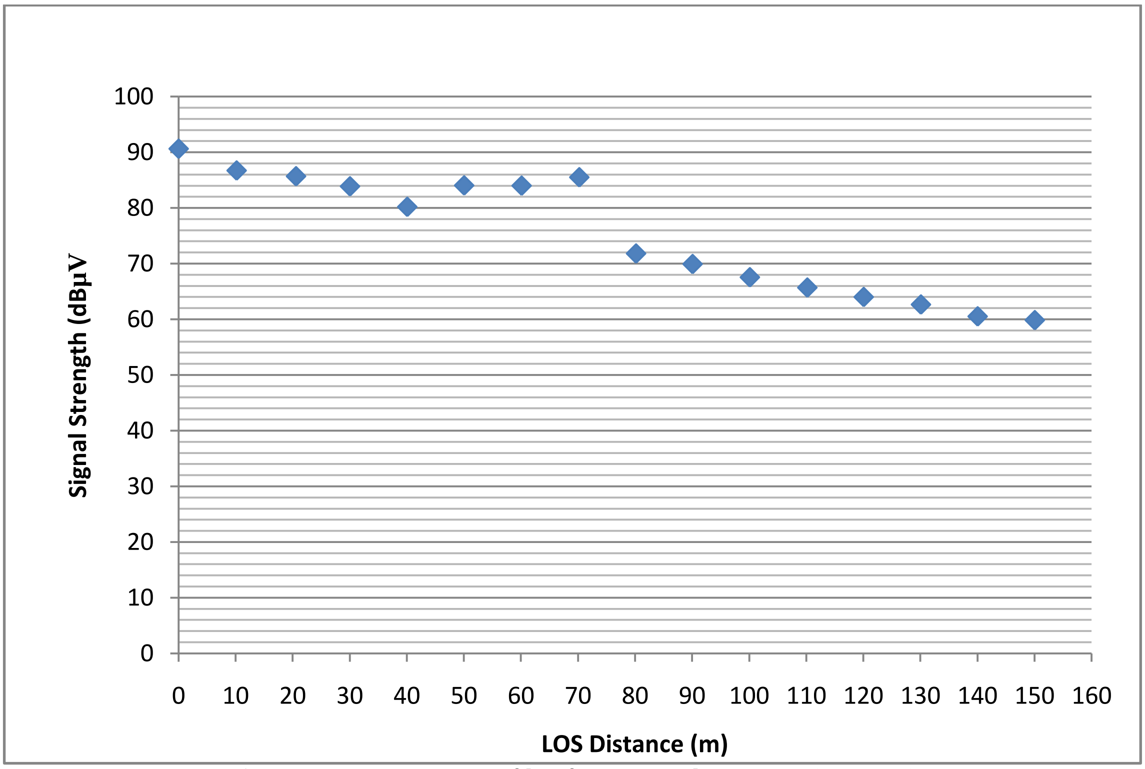

Figure 7: Propagation Profile of FUTA Radio Station (93.1 FM)

Results obtained with FUTA radio station is presented in Table 4 while Fig. 7 indicates the relationship that exists between signal strength and line-of-sight distance. It was observed that the graph did not completely obey "inverse square law" (decrease in signal strength as a result of increase in distance) this was because there were metal poles situated at some points along the transmission path taken (plates 3); these poles acted as signal strength booster there by increasing the strength of the signals towards them. Comparing the graphs obtained from this research to an ideal situation where there are no boosting antennas, the signal strength would decrease as the transmission distance increases and vice versa with reference to the base station.

 

Plates 3: Image of Metal Poles found along the Path taken.

V. CONCLUSION

Based on the work done so far, it was generally observed that signal strength reception is a function of distance, natural and man-made environment of the transmission path taken by the signal. Attenuation of radio waves increases with increasing transmission line-of-sight distance as well as the number of absorbers situated along the path taken but increases whenever reflectors are encountered.

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