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# Improving Signal Reception in Cdma20001x Network Using Antenna Diversity Technique

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***ABSTRACT:- This paper focuses on improving signal reception in CDMA20001x network using antenna diversity technique. Field data were collected from a CDMA20001X network located in Enugu, the capital of Enugu State of Nigeria. The field data collected include data for the measurement of received signal strength from a transmitting base station which was carried out with spectrum analyzer of model RG382B.The distances of the measurement points from the transmitting base station was recorded using the global positioning system. Also, in this paper the received signal strength using two antenna systems were obtained from simulation Result obtained from the field data showed that the pathloss exponent of the characterized environment was 3.60 while the result obtained using antenna diversity resulted in pathloss exponent of 2.51.***

*Key words*: **antenna diversity, pathloss exponent, CDMA20001X, signal reception**

## I. INTRODUCTION

Wireless communication services have been growing at a very rapid rate in recent times. Today, the requirements of wireless communication by subscribers to provide high voice quality, data rate services, multimedia features, and lightweight communication devices is also increasing at a rapid rate. But the wireless operators cannot meet with such demand from these subscribers since the communication channel suffers impairments that reduce signal reception on the wireless network [1].These impairments include attenuation, distortion, multipath fading, reflection, and refraction [2]. Several attempts have been made by these wireless network operators to provide the satisfactory voice and data rate services by deploying more base stations to the existing ones. But, this method is not cost effective and economical option since the wireless operators are interested in maximizing their profit. Therefore, the need for a new technique that will be efficient and cost effective way of improving the signal reception on the wireless network without the relocation or addition of more base stations to the existing ones has emerged. This technique is called antenna diversity. Diversity is an effective means of reducing multipath fading that reduces signal reception in wireless network and it improves the performance over a fading radio channel [3]. The various types of diversity include: frequency, time and space diversity [4]. Space diversity also known as antenna diversity is one of the several wireless diversity schemes that uses two or more antennas to improve the quality and reliability of a wireless link [5]. Space diversity is effective in mitigating multipath situations since multiple antennas offer the receiver several observations of the same signal and each antenna experiences a different interference environment. The basic idea of using antenna diversity is that if one antenna is experiencing a deep fade, it is likely that another one has a sufficient signal and collectively the entire system can provide a robust link also decrease the number of drop-outs and lost connections.

## II. DIVERSITY COMBINING TECHNIQUE

There are different types of diversity combining techniques used in space diversity for improving the system performance. The combining techniques are selection combining, equal gain combining and maximal ratio combining [6].

**(I) Selection combining**

In selection combining, the receiver monitors the Signal to Noise Ratio (SNR) of all branches, selects and uses the information from the branch with the largest SNR. It is the simplest of the diversity combining techniques.

**(II) Equal gain combining**

Equal gain combining requires the receiver to coherently sum the signals received through all channels in order to increase the available SNR at the receiver.

**(III) Maximal ratio combining**

Maximal Ratio Combining (MRC) is the most effective of the combining techniques because it presents at the output of the receiver a SNR that is the direct sum of all individual SNR's in the branches.

### *A. MATHEMATICAL ANALYSIS OF TWO-BRANCH MAXIMAL RATIO COMBINING*

Figure1 shows the baseband representation of a typical two-branch maximal ratio combining. The mathematical analysis of the two branch maximal ratio combining is as follows:

Let the channel between the transmit antenna and receive antenna x be denoted by $h_x$ and the channel between the same transmit antenna and receive antenna y be denoted by $h_y$. These channels at time t can be modelled by a complex multiplicative distortion $h_x(t)$ for receiver antenna x and $h_y(t)$ for receiver antenna y. Thus, the

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channels $h_x(t)$ and $h_y(t)$ are given by the expressions [7]:

$$h_x(t) = h_x = \alpha_x e^{j\theta_x} \quad (1)$$

$$h_y(t) = h_y = \alpha_y e^{j\theta_y} \quad (2)$$

It is observed that as the signals $s_x, and\ s_y$ transverse these channels, noise and interference are added to the signals reaching the two receivers x and y. Therefore, the resulting received baseband signals on the x and y antennas are expressed as:

$$r_x = h_x\, s_x + n_x \quad (3)$$

$$r_y = h_y\, s_y + n_y \quad (4)$$

Therefore, the receiver combining scheme, $\hat{S}_o$, for two branch MRC is determine as follows:

$$\hat{S}_o = h_x^* r_x + h_y^* r_y \quad (7)$$

Substituting the values of $r_x$ and $r_y$ into equation (7)

Where

*$s_x$, and $s_y$ are the signals reaching the antenna x and antenna y*

respectively. Also, $n_x$ and $n_y$ represent receiver noise and interference on the x and y channels respectively. Assuming $n_x$ and $n_y$ are Gaussian distributed, the maximum likelihood decision rule at the receiver for the received signals is to choose signal if and only if :

$$d^2(r_x, h_x\ s_i) + d^2(r_y, h_y\ s_i) \le d^2(r_x, h_x\ s_k) + d^2(r_y, h_y\, s_k) \quad (5)$$

But, the expression $d^2$(x, y) is the squared Euclidean distance between signals x and y and is expressed as follows:

$$d^2(x, y) = (x-y)\,(x^* - y^*) \quad (6)$$

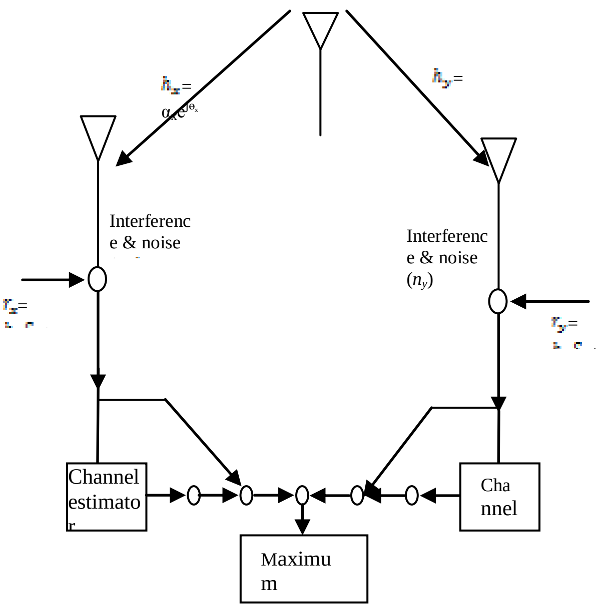


**Fig1: Baseband representation of the classical two-branch MRC**

$$\hat{S}_o = h_x^*(h_x\, s_x + n_x) + h_y^*(h_y s_y + n_y) \quad (8)$$

$$\hat{S}_o = (\alpha_x^2 + \alpha_y^2) S_x + h_x^*\, n_x + h_y^*\, n_y \quad (9)$$

Expanding equation (5) and using equation (6) and (9), we choose the highest signal, $S_i$, if and only if :

$$(\alpha_x^2 + \alpha_y^2)|S_i|^2 - \hat{S}_o S_x^* - S_x^* S_i \le (\alpha_x^2 + \alpha_y^2)\ |S_k|^2 - \hat{S}_o S_k^* - S_x^* S_k, \text{for } i \ne k \quad (10)$$

For Phase Shift Key (PSK) signals (equal energy constellations)

$$|S_i|^2 = |S_k|^2 = E_s \quad (11)$$

Where $E_s$ is the energy of the signal. Therefore, for PSK signals, the decision rule in equation may be simplified to choose $S_i$ if and only if:

$$d^2(\hat{S}_o, S_i) \le d^2(\hat{S}_o, S_k), \text{ for } i \ne k \quad (12)$$

## III. METHODOLOGY

In order to ascertain the efficiency of the wireless network under consideration, some field data were collected from a third generation wireless network which is a CDMA 20001x network belonging to one of the wireless networks in Nigeria. The field data include measurement of Received Signal Strength (RSS) which was carried out from the base station belonging to Multi-links Nigeria Limited. The base station located in Enugu, the capital of Enugu State has the following parameters: Cell Site: EN 05, frequency, f =887.86MHz, transmitted power, Tx =40 dBm. The RSS was measured with the help of ray-tracer software installed in the spectrum analyzer equipment which also measures the strength of received signal. The elevations, co-ordinates, and distances from the transmitting base station and the measurement points were also recorded with the help

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global positioning system. The field data was collected from one sector of the antenna is shown in Table 1. In the simulation, the testbed environment as well as the transmitting base stations and its features were re-created.

**Table 1: Average of the Measurement of RSS carried out on the Multi-links network at Enugu. Time of Measurement: 10.00am -3.00pm: (CellSite: EN 05, Frequency, F=887.86MHz, Transmitted Power,Tx =40 dBm).**

| Distance(m) | RSS (dBm) |
|---|---|
| 100.00 | -67.94 |
| 200.00 | -74.16 |
| 300.00 | -86.84 |
| 400.00 | -87.04 |
| 500.00 | -91.64 |
| 600.00 | -99.33 |
| 700.00 | -103.13 |

**Table 2: RSS from conventional antenna and RSS using antenna diversity**

| D(m) | RSS(dBm):conventional antenna | RSS(dBm) :antenna diversity |
|---|---|---|
| 100.00 | -67.94 | -67.94 |
| 200.00 | -74.16 | -78.85 |
| 300.00 | -86.84 | -85.26 |
| 400.00 | -87.04 | -89.79 |
| 500.00 | -91.64 | -93.31 |
| 600.00 | -99.33 | -96.18 |
| 700.00 | -103.13 | -98.61 |

It was assumed that the same antenna was used in the simulation. Therefore, the RSS from one antenna was recorded as well as with two antennas. The RSS data from the simulation is shown in Table 2.

## IV. DATA ANALYSIS

Figure 2 shows the graphical representation of the received signal strength obtained from field measurement. Figure 2 shows the rate at which pathloss increases as the distance from the base station increases. The pathloss exponent of the test bed area is 3.60 as computed from the measured data**.** The pathloss exponent of 3.60 shows the variation of signal loss in the test bed environment or characterized environment. Thus, Figure 2 serves as the basis for accessing the impact of the antenna diversity on the code division multiple access networks.

It is observed from Figure 3 that there is a greater improvement on the performance of the CDMA20001x network using antenna diversity system in improving the signal reception in the network as observed from the value of pathloss exponent of 2.51 unlike that of 3.60 obtained from using single conventional antenna on the network

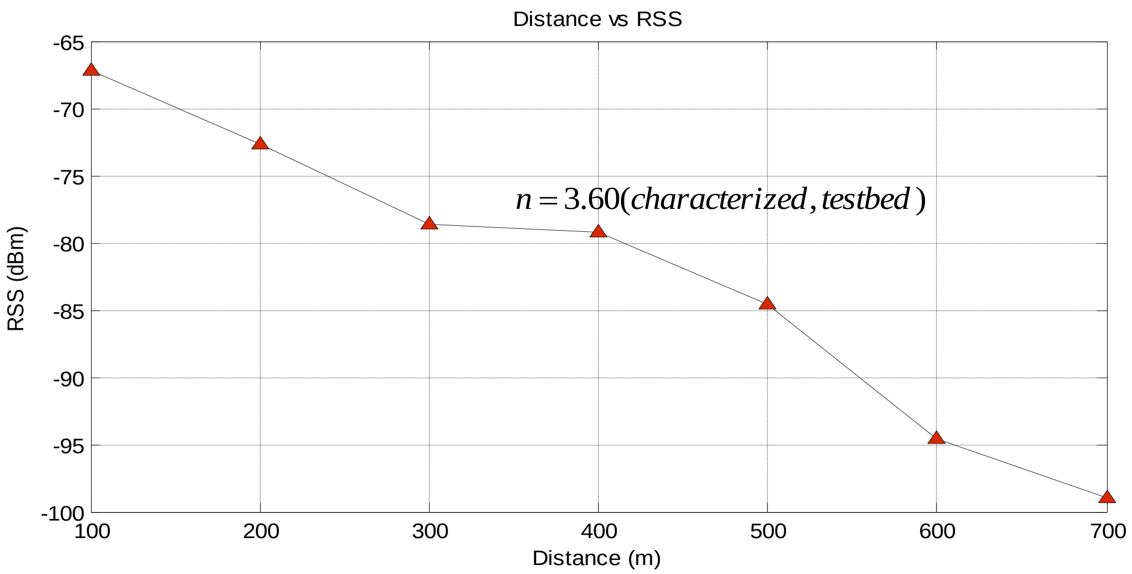


**Fig 2: RSS vs. distance for CDMA20001X network**

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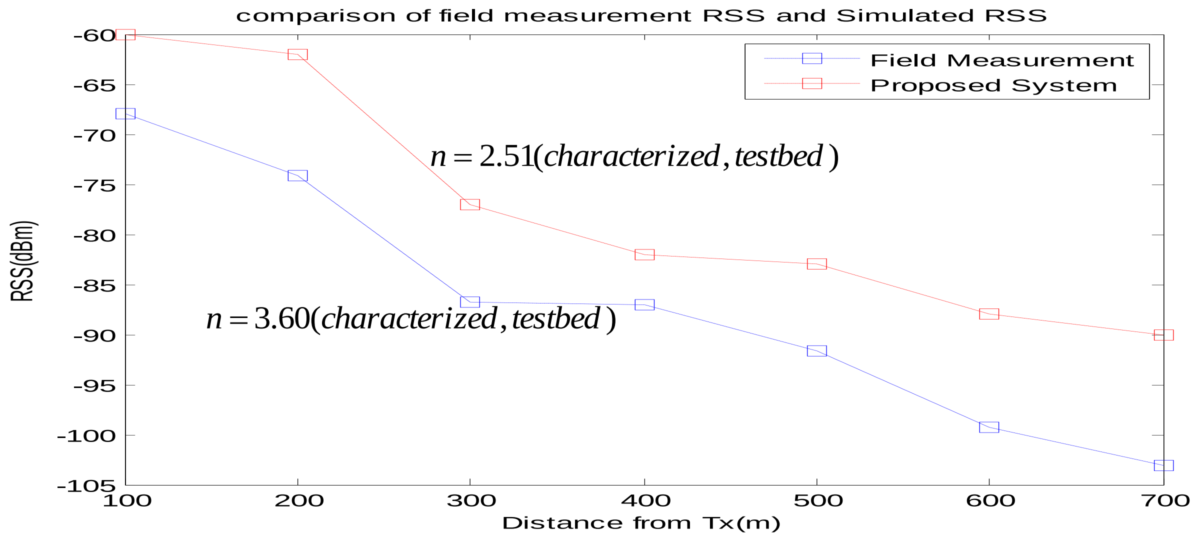


**Fig 3: Response of antenna diversity in improving the signal reception on network**

## V. CONCLUSION

It has been shown that improvement on signal reception on the network has been achieved using antenna diversity. Thus, in using antenna diversity, deep channel fades are absent and limited amount of transmitted power is enough to compensate for fading. The technique does not require any feedback from the receiver to the transmitter.

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