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Propagation Analysis of Radio Frequency (RF) Signal of Love FM Transmitter in Port Harcourt, Nigeria

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Abstract: *This Paper Presents a comprehensive investigation of the RF Signal Strength of Love FM Transmitter in Port Harcourt, Nigeria. The Signal measurement were carried out at different locations with the aid of a GPS band scanner. A maximum distance of 6KM was chosen with respect to the North, South, East and West of the Transmitter. The measuring points have interval of 1km from each other, summing up to 24 different measuring points. The result of the measurement was used to plot the attenuation decay curve of Love FM Radio station's transmitting antenna. The personal computer used for the exercise displays the outputs and results such as the Distance, electromagnetic field strength, spectrum analysis and Radio Data System analysis generated from the GPS band scanner The analysis shows that Love FM transmitter antenna is not practically isotropic since it Signal Strength Values are not equal in all directions. It was observed that at location very close to the transmitter the Value of the signal strength is considerably high and at some locations far from the transmitter the value of the signal Strength is low. It was also observed that at some locations precisely some areas in oyigbo there was no signal coming from the transmitter. The band scanner was having a voltage value of 0 dBμv. This shows that terrain can also play a major role in limiting broadcast range. The Value of the Received Signal Strength is a function of the transmitter Power, the Antenna Gain, the antenna height, the topography of the terrain.*

Keywords*: Antenna, Band Scanner, Signal, Transmitter*

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I. Introduction

Electromagnetic field strength can be defined as a measure of the strength of an electric field at a given point in space, equal to the force the field will induce on a unit of positive electric charge at that point. It can also be called electric field intensity. A radio wave is an Electromagnetic wave which emanates from a radiating source. The radio wave assumes all the properties of a plane wave; the wave-front is the plane which contains the Electric (E) and Magnetic (H) vectors and is at right angle to the direction of propagation and power flow. Usually, it is convenient to carry out studies in terms of the electric component, E of the wave which is known as the electric field strength of the wave (Radio wave). The quantitative measure of the strength of an Electric field is known as the Electric field strength (Intensity) measurement [1]. One of the main characteristics that define an electromagnetic field (EMF) is its frequency or its corresponding wavelength. Fields of different frequencies interact with the body in different ways. One can imagine electromagnetic waves as series of very regular waves that travel at an enormous speed, the speed of light. The frequency simply describes the number of oscillations or cycles per second, while the term wavelength describes the distance between one wave and the next. Hence wavelength and frequency are inseparably intertwined: the higher the frequency the shorter the wavelength. [2]

Love FM broadcasting station is a privately owned company under a unit called MULTIMESH BROADCASTING and operates on a Frequency of 97.7 Megahertz. This station started operations on the 5th of August, 2008 this unit runs under MULTIMESH GROUP. Love FM Studio is situated at 2nd Artillery in Port Harcourt, with their Studio Transmission Link (STL) antenna connecting to their base at Eleme, the antenna at Eleme receives the radio signal and transmits Radio Frequency (RF) Signal round Port Harcourt and further up to Aba, Abia state and some other part of the states. Today 66.6 percent of the population in Port Harcourt alone listens to love FM broadcasting station. Figure 1 below shows the location of the Studio and Transmitter location in Port Harcourt. STL system encodes program content at a studio site and transports this content wirelessly over a licensed frequency to a far-end transmitter site. This wireless radio link is unidirectional. This system is used since the Radio station transmitter tower is located very far away from the studio. This radio station can use a radio STL system to transport program content to the receiver, located at the transmitter site. The output processor is connected to the sending (transmit) unit. The output of the receiver is then connected to the transmitter as shown in figure 2 below.

Band Scanner GPS" is a tool to evaluate FM broadcast band and to log station identification parameters such as electromagnetic field strength, band width, received power at a distance and radio data system length. "Band Scanner GPS" is a Google Earth compatible tool for visualization of FM Radio measurements. When running any campaign with the "Band Scanner GPS", results will be saved in a Log file. The Band Scanner GPS was used to carry out the Signal Strength measurement at the specified locations [3].

This paper presents the Comprehensive investigation of RF Signal strength due to Love FM transmitter located at Eleme, Port Harcourt. It is essential to know that starting a new radio station requires conducting a license proof of performance for the transmission system, arrange for studio and transmission equipment, establish the station format, location of the transmitter and antenna etc. But most importantly, carry out field strength assessment to demonstrate that the radiated signal strength will meet their requirements (Compliance Survey). This measurement is essential to be performed for radio transmitters to discover the areas with less signal strength and also to determine the Radio coverage areas

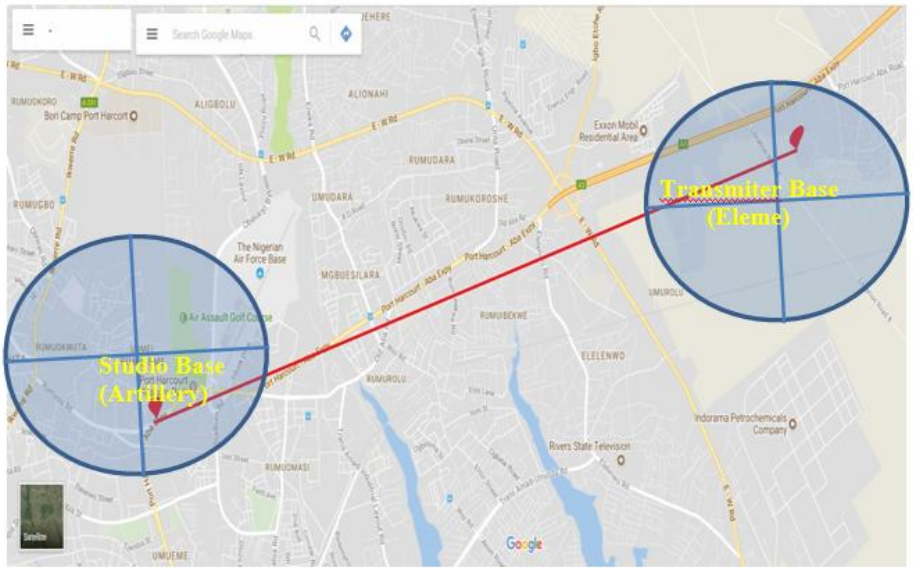

Figure 1: Map of Love FM Radio studio to the transmitter in Eleme, Port Harcourt.

The following are the characteristics of Love FM 97.7 FM transmitter; Transmission Power 7500W (7.5KW), Transmitter design power 6KW, Running power 3.0KW, Transmitter line loss 0.3db, Antenna height at the radio station 85ft, Antenna Height at the Base 350ft, Antenna Base 8ft, Antenna Type: Highly directional LOS antenna , Gain 3.2dBi, Strong signal covered area 8,573 km2, Weak signal covered area 17,647 km2, Strong signal population reached 4833816 pop, Weak signal population reached 8,229,551 pop, Antenna Load impedance 20 ohms, Modulation Format: QPSK (QUADRATURE PHASE SHIFT KEY), Source of Power supply: PHED, Inverter Generator, and the inverter power is 3-phase 30KVA(415V)

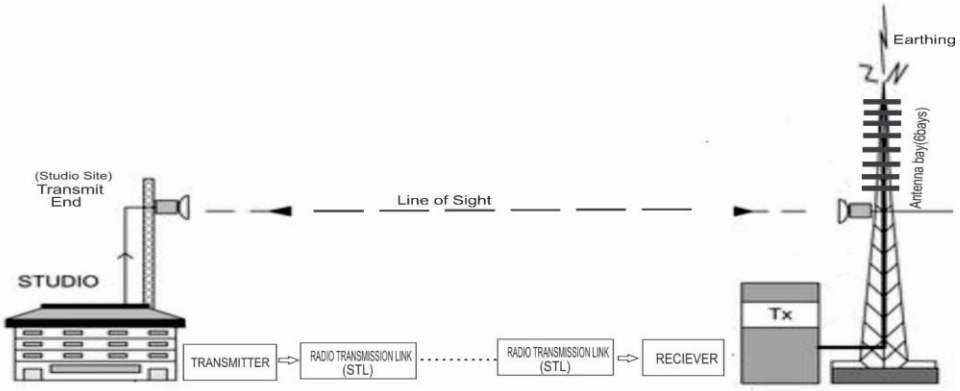

Figure 2: Shows the Transmission Link from the studio to the transmitting antenna.

II. Electromagnetic field strength

In telecommunications, field strength meter is a measuring device which measures the signal strength caused by a transmitter. In ideal free space, the electric field strength produced by a transmitter with isotropic radiator is readily calculated as.

$$E_r = E_0\left(\frac{4\pi h_t h_r}{\lambda d^2}\right) \quad (1)$$

And

$$E_0 = \sqrt{30 P_t G_t} \quad (2)$$

Where, Pt is the output power, G_t is the antenna gain of the transmitter and E_r is the electric field strength received at a distance.[4]

Since we are concerned with the radiated field generated from the antenna, we will consider the point source radiator or highly directional antenna which radiates (receives) much more efficiently in some directions than in others.

Hence, Power density, Pd at the point Q is:

$$P_d = \frac{P_t}{4\pi r^2} \text{ watts/m}^2 \quad (3)$$

Poynting theorem defines the relationship between the power density to the E-field and H-field vectors as defined below:

$P_d = E \times H$ watts/m^2 (4)

The magnitude of the power density is thus:

$$|P_d| = EH = \frac{E^2}{120\pi} \quad (5)$$

where $120\times\pi$ is the impedance in free space or approximately 377Ω

From the above, we can see that $\frac{E}{H} = 120\pi, thus, \frac{E}{120\pi} = \frac{P}{4\pi r^2}$ (6)

Hence, the RMS value of the E field can be calculated from

$$E = \frac{\sqrt{30P}}{r}\ V/m \quad (7)$$

A Highly directional antenna is considered to have a passive power gain, G=1 dBi. if an antenna with gain were placed at point 0, the power received at point Q would be increased by G_t. Hence the field strength at point Q will be increased.

$$E = \frac{\sqrt{30 P_t G_t}}{r}\ V/m \quad (8)$$

Where P_t is the transmitter power, G_t is the antenna gain. [5]

Similarly, for the antenna with gain G_t equation (8) can be rewritten as:

$$P_d = \frac{P_t G_t}{4\pi r^2}\ V/m \quad (9)$$

III. Materials And Methods

3.01 Field Strength Measurement Equipment's and Procedure

The equipment used to carry out the electromagnetic field strength measurement is shown in figure 3 below This includes:

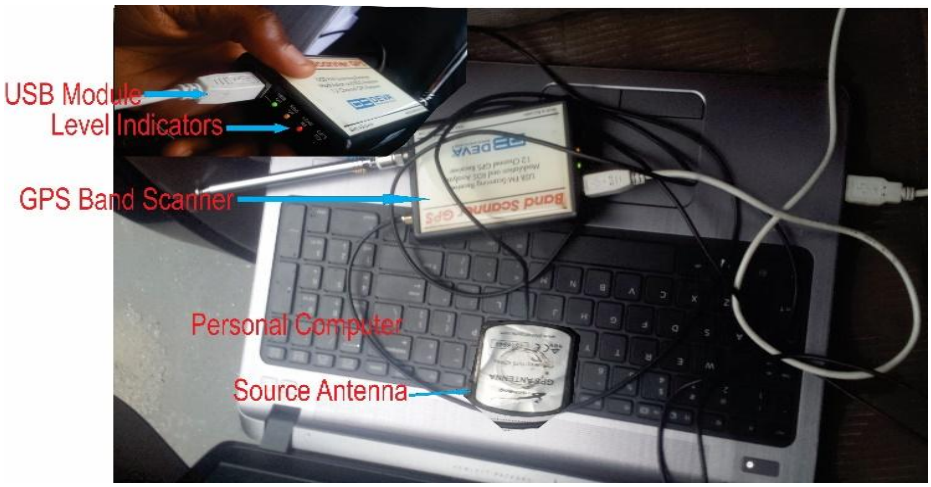

Figure 3: Measuring Equipment used in the field

- **A Band GPS Scanner**- which is the receiver system that is used to determine the how much Electromagnetic Field Strength (EMF) power and Voltage in (dBμv) the transmitter is radiating at a particular location. Love FM 97.7 frequency was imputed on the GPS Band Scanner to synchronize with the transmitter at the base station. Level Indicators on the Band scanner are used to display the level of signal strength at that location as shown in Figure 4

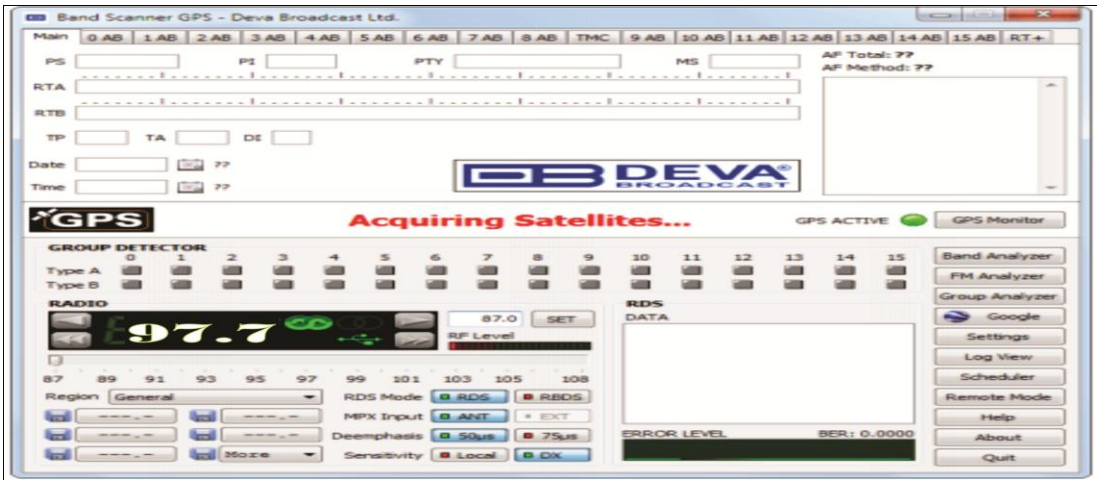

Figure4. Band Scanner GPS

- **GPS antenna**- This antenna is used to create a radiation pattern that illuminates the test antenna. The antenna also sensitive enough to indicate the coordinates of each measured location and also indicates the distances covered.
- **FM Antenna**- provides the audio signal of the tuned station for listening.
- **A positioning system** - This system is used to rotate the test antenna relative to the source antenna, to measure the distance moved away from the referenced transmitter as a function of angle and also to reduce the fluctuation of signals that are already saved on the band scanner**.**
- **A module such as a USB cord** - To power the receiver system and also serves as a medium or interface for the visual output.
- **A Personal Computer (PC) system-.** The USB Cord from the Band Scanner is connected to the Computer serves as the Visual output for the GPS band scanner as shown in figure 5

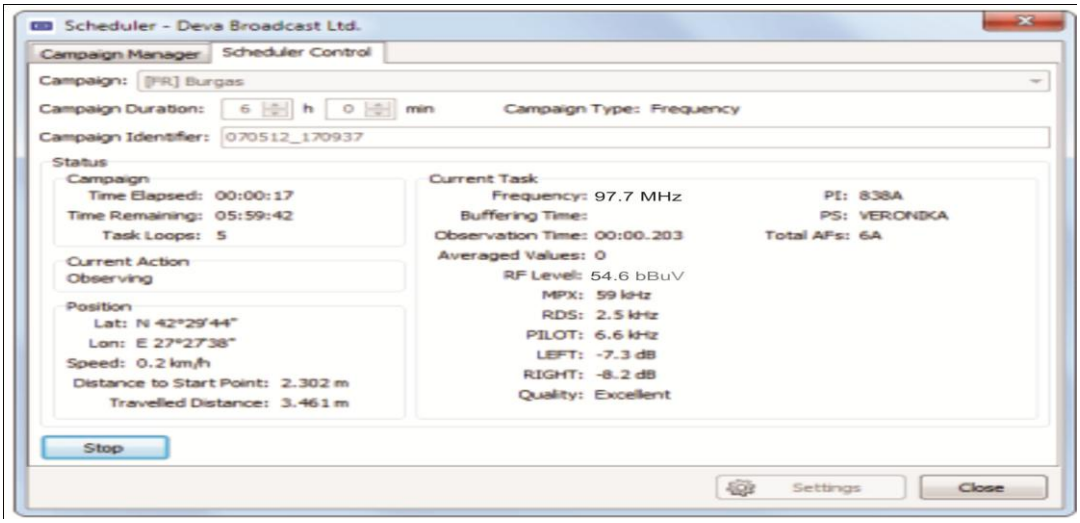

Figure 5: Image of Scheduler-Band Scanner GPS

***3*.02 Selection of Data Points on the Map**

As shown on the map of figure 6 below, six circles are drawn on the map taking Love FM Transmitter located at Eleme as the Centre point, a distance of 6KM radius at the four cardinal points taking 1km apart from the transmitter was measured at different locations due north, south, East, and West respectively. This was easily achieved with the use of Google Earth application as it depicts the location of the transmitter after

inputting its coordinates. With the help of Google Earth visual, 1km intervals from the transmitter were easily projected and a measurement is taken with help of the GPS band scanner. The coordinates gotten from Google Earth application were easily imputed on the GPS Band Scanner since it's a Google Earth Compatible tool and can log stations identification parameters such as electromagnetic field strength, bandwidth, received power at a distance and radio data system strength. [3] The imputed parameter was exported and converted to a KMZ format and view on Google Earth shown in figure 5 above.

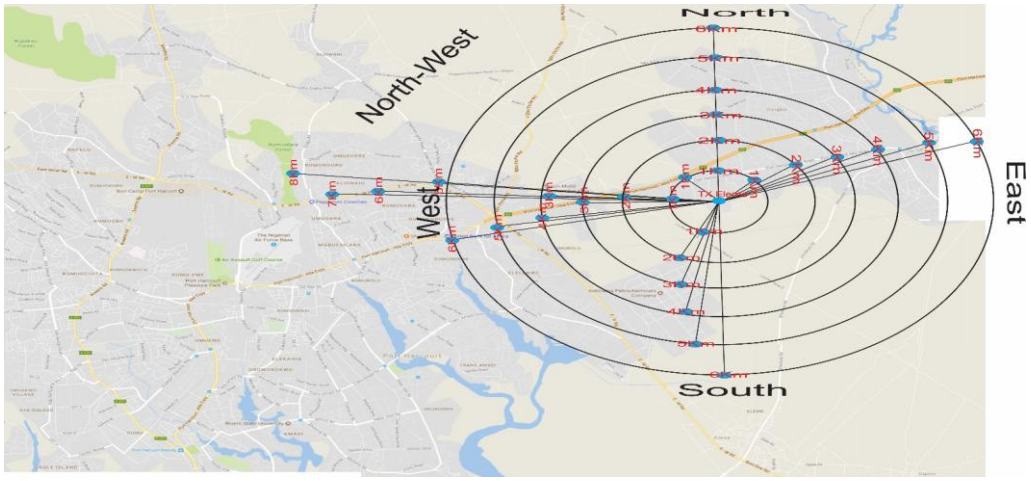

Figure 6: Geographical Map of the measured locations

The result of the measurement was used to plot the attenuation decay curve of Love FM 97.7 station's transmitting antenna. The personal computer used for the exercise displays the outputs and results such as the Distance, electromagnetic field strength, spectrum analysis and Radio Data System analysis generated from the GPS band scanner as the Deva Broadcast Ltd Software was launched and Love FM frequency 97.7 was imputed

IV. Presentation Of Data

Table 1 to Table 4 shown below Present the Electric Field Strength measured in Port Harcourt at different locations, Time and date.

Table 1: Measured Field Strength Value at Locations Due West

Aba Express Way to Eleme						**Date: 21st July 2017**
S/N	**Description**	**Coordinates**	**Distance (M)**	**Time** (hrs)	**Emf Voltage (dBµv)**	**Field Strength (µV/M)**
1	Fidelity Bank, Rumuigbo	Lat. $4^0$50'29.92'N Log. $7^0$2'0.74'E	6000	15.21	20.9	0.00348
2	CIWA, Aba Road, after Artillery	Lat. $4^0$50'43.55'N Log. $7^0$2'35.27 E	5000	15.23	20.5	0.0041
3	Shell RA Bus Stop	Lat. $4^0$50'55.00'N Log. $7^0$2'59.77'E	4000	15.26	35.6	0.0089
4	Pagoda, Obia Rd, Eleme	Lat. $4^0$51'3.20'N Log. $7^0$3'32.36'E	3000	15.28	27.3	0.0091
5	Nido Gas, Eleme	Lat. $4^0$51'13.60'N Log. $7^0$4'3.17'E	2000	15.30	54.6	0.00273
6	Oando Filling Station, Eleme	Lat. $4^0$51'31.13'N Log. $7^0$4'33.72'E	1000	15.34	43.7	0.0437

Table 2: Measured Field Strength Value at Locations Due South

East-West Road to Onne						**Date: 21st July 2017**
S/N	**Description**	**Coordinates**	**Distance (M)**	**Time** (hrs)	**Emf Voltage dBµv)**	**Field Strength (µV/M)**
1	Total Filling Station, Onne Rd	Lat. $4^0$50'47.17'N Log. $7^0$4'33.38'E	1000	15.7	36.9	0.0369
2	Diala Oil, E-W Rd, Rumiolu	Lat. $4^0$50'20.27'N Log. $7^0$4'58.46'E	2000	15.39	27.4	0.0137
3	Mikoatex Safety & Logistics	Lat. $4^0$49'51.20'N Log. $7^0$5'19.79'E	3000	15.41	38.7	0.0129
4	Eco Bank, E-W Rd	Lat. $4^0$49'20.89'N	4000	15.45	16.2	0.0054

		Log. $7^0$5'32.50'E				
5	NNPC Station	Lat. $4^0$48'51.68'N Log. $7^0$5'47.47'E	5000	15.47	20.6	0.00412
6	ExproTech Nig. Ltd	Lat. $4^0$48'22.99'N Log. $7^0$6'4.66'E	6000	15.50	54.6	0.0091

Table 3: Measured Field Strength Value at Locations Due East

Aba Express Way to Oyigbo						**Date: 21st July 2017**
S/N	**Description**	**Coordinates**	**Distance** (M)	**Time** (hrs)	**EMF Voltage** (dBμv)	**Field Strength** (μV/M)
1	F&G Gas Station, Oyigbo	Lat. $4^0$51'31.13'N Log. $7^0$4'33.72'E	1000	16.36	38.5	0.0385
2	Oasis Plaza Trader Park, Iriebe	Lat. $4^0$51'45.58'N Log. $7^0$5'33.65'E	2000	16.40	48.6	0.0243
3	Garlic Oil, Aba Express Way	Lat. $4^0$51'55.48'N Log. $7^0$6'5.22'E	3000	16.43	39.6	0.0132
4	Kings World Boutique Oyigbo	Lat. $4^0$52'2.15'N Log. $7^0$5'37.70'E	4000	16.46	26.5	0.006625
5	Conoil Station Oyigbo	Lat. $4^0$52'9.36'N Log. $7^0$7'9.50'E	5000	16.49	18.8	0.00376
6	F&G Gas Station, Oyigbo	Lat. $4^0$51'31.13'N Log. $7^0$4'33.72'E	1000	16.36	38.5	0.0385

Table 4: Measured Field Strength Value at Locations Due North/East

Eneka to Rumuodara						**Date: 21st July 2017**
S/N	**Description**	**Coordinates**	**Distance** (M)	**Time** (hrs)	**EMF Voltage** (dBμv)	**Field Strength** (μV/M)
1	De.World Intr.School, INTEL RD.Eleme Rd	Lat. $4^0$52'5.30'N Log. $7^0$5'12.83'E	1000	17.01	54.7	0.0544
2	DLBC, Rumuodara. PH	Lat. $4^0$51'56.55'N Log. $7^0$51'56.55'E	3000	17.06	42.0	0.0095
3	Atlantic Affairs Rumuodara	Lat. $4^0$51'46.77'N Log. $7^0$2'21.94'E	5000	17.09	47.5	0.00763
4	Pepperoni, Rumuodara	Lat. $4^0$51'37.45'N Log. $7^0$1'45.96'E	6000	17.11	45.8	0.00441
5	Wisdom Gate, Eligbolo	Lat. $4^0$51'52.08'N Log. $7^0$1'9.68'E	7000	17.14	30.9	0.00468
6	Unity Gas, Eligbolo	Lat. $4^0$52'17.40'N Log. $7^0$0'48.98'E	8000	17.17	37.5	0.014

V. Results And Discussion

The results obtained from the field strength values taken during each 1Km interval measurement due EAST, WEST, and NORTH and SOUTH were plotted against the distance as shown in the figures 6,7,8 and 9 below.

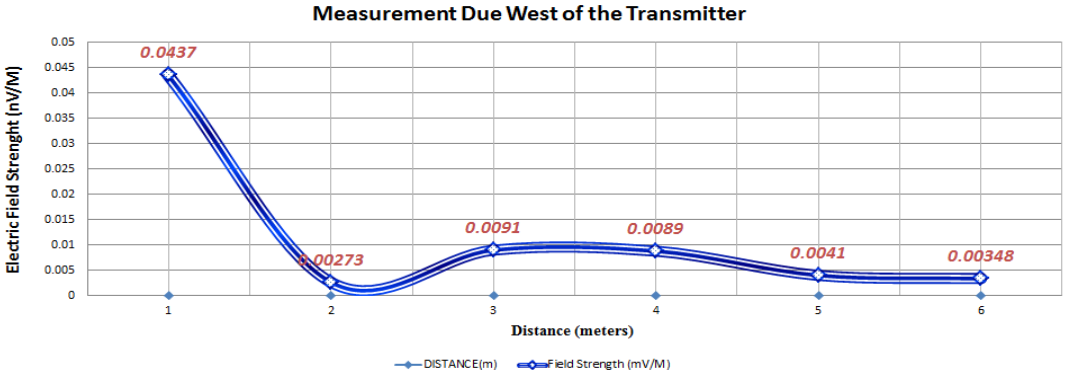

Figure 6: Graph of EMF against Distance due West

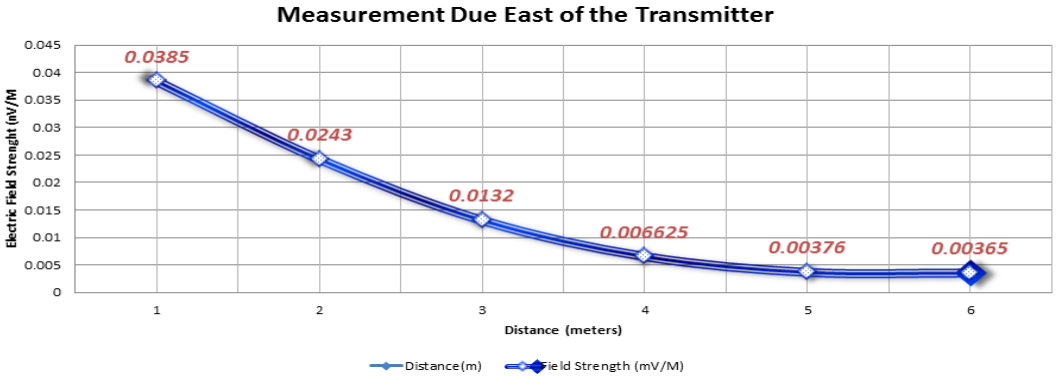

Figure 7: Graph of EMF against Distance due East

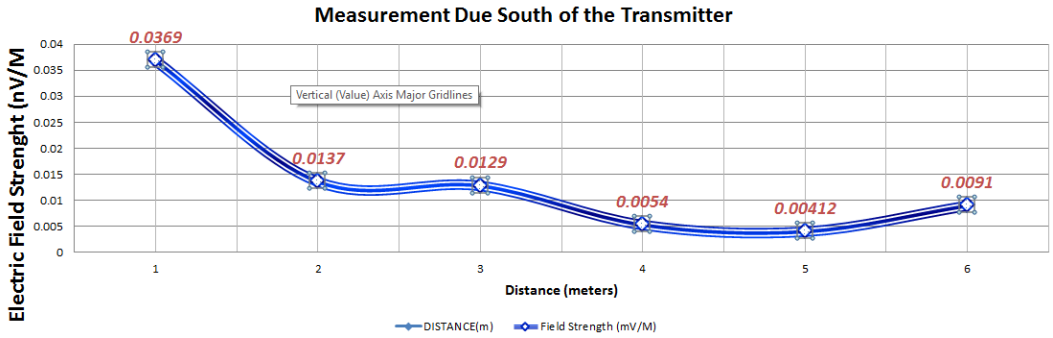

Figure 8: Graph of EMF against Distance due South

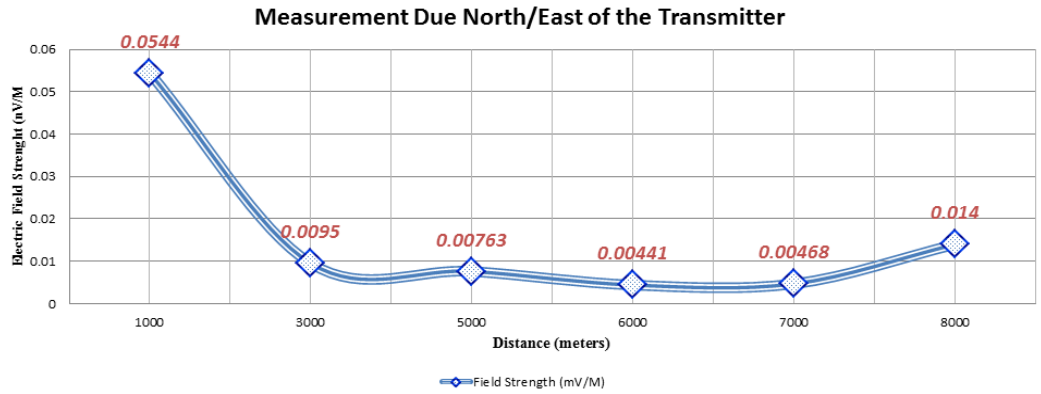

Figure 9: Graph of EMF against Distance due North-East

From the graphical representation of figure 6, it is observed that at 1KM away from the transmitter where the field strength voltage value was calculated to be 0.0437µV/m, the signal was very high though it was very near to the transmitter and had a clear weather until the signal decreased to 0.00273µV/m. However, between 3km to 4km, there were only slight changes, but the signal reduced at 5km and 6km probably due to the distance. While From figure 7 to 9 can only be understood that signal reduces as we move away from the transmitter. It was observed that at locations very close to the transmitter the signal strength is considerably high and at some locations far from the transmitter the signal level is low.

VI. Conclusion

This paper has demonstrated the measurement of Electromagnetic field strength of Love FM 97.7 transmitter located at Eleme with the use of a GPS Band Scanner. From the measurement carried out, it is safe to say that at distances very close to the transmitter, the signal value is high with excellent signal quality while at distances far away from the transmitter the received signal value is low. It was also observed that at the time the weather changed the signal strength reduced drastically. It was also observed that at some locations precisely some areas in oyigbo there was no signal coming from the transmitter. The band scanner was having a voltage value of 0 dBµv. This shows that terrain can also play a major role in limiting broadcast range.

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