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Investigation of the Effect of Atmospheric Temperature on Signal Strength Generated by FM Transmitter in Imo State, Nigeria

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Abstract: ***This study reviews the effect of temperature on the signal generated by the frequency modulated transmitter of the Imo state broadcasting cooperation (Orient 94.4 FM) within some selected routes in Imo State, Nigeria. The research was carried out between the months of April and June 2016. The equipment used to measure signal strength in the study areas is a constructed Signal Strength Meter (SSM). Holo Ambient Temperature Pro {Thomas Otero (H3R3T1C) was used to measure the atmospheric temperature along the routes of signal measurement. Measurements were taken in different months, on different days, and at a different time of the day and different temperature. The average results of these measurements were then taken and the data obtained from the measurements were tabulated and subsequently plotted in a graph to ascertain the variation in signal strength along the different routes. It was observed from this research that the rise in atmospheric temperature will lead to a drop in strength of the signal generated by Orient 94.4 FM transmitter. Thus, it can be postulated that temperature varies inversely to the signal strength provided the transmission parameters remain constant.***

Keywords: Temperature, Signal Strength, Transmission, Measurement, Transmitter

1. Introduction

It has been discovered that signal strength generated by radio is affected by temperature and relative humidity. Signal strength decreases as the temperature rises and increases with increasing relative humidity [1].Most wireless systems operating outdoors are unprotected to varying weather conditions, which may result in intense deterioration in network performance [2]. Consequently, it is important that the factors affecting radio network performance are discovered in other to lessen their effect and adjust to changing weather condition. This weather variation is a significant problem of humanoid interest as they influence man's day-to-day existence in numerous ways. These variations are usually measured with facile measuring devices or by noting resultant variations in parameter reliant on the weather metrical being measured. The best way to do this is by determining the radio networks feature [3]. In an ideal environment, radio signals are affected by earth's shape, atmospheric parameter like temperature, humidity, wind, and interaction with the object on the ground such as hills, trees, water body, valley, mountains, buildings etc. [4].

The quality of radio frequency networks in an actual environment is affected by various atmospheric components. The atmosphere may reflect the radio frequency network to the earth as a result of its index of refraction due to its pressure, temperature, wind, and humidity which are elements of weather [5].Presently, the physical and weather occurrences related to the several active methods in the actual nearby external environs (e.g. the external stratum), are inadequately inferred. Through the accurate description of occurrences in the actual ecosphere, there is some possibility for finding an experimental procedure that relates strongly with actual ecosphere facts and consequently uses as a way of calculating these definite methods. This can then be used to correctly describe the atmospheric influence in the atmosphere on radio frequency waves [6].

The moderately hot air is seen near the earth surface. As altitude increase, the air steadily becomes cooler in the troposphere segment of the atmosphere. Most times, a rare condition occurs in which warm air layers appear beyond cool air layers. This is known as temperature transposition or temperature inversion. These temperature transpositions result to channels of cool air such that radio wave is transported by the channel overextended space further from expectancy [7]. Tropospheric ducting mainly arises in the springtide and drops owing to temperature transposition where the temperature of the atmosphere really increases with elevation. Temperature inversion occasionally enables some other frequency modulated broadcasting stations positioned outside line-of-site to obstruct the endemic stations on same frequency. The obstructing station can most times be robust enough to dominate endemic stations such as Orient 94.4 FM. This commonly happens in the early hours of the morning and its effects will disappear totally by afternoon [8].

Most times the signals of Imo State Broadcasting Corporation radio station (Orient 94.4 FM) basically do not cover areas on the fringe of the state. Terrain, technical deficiencies from the transmitting station and atmospheric parameter such as temperature leads to a poor signal reception in those fringe areas. The aim of this research is to investigate the effect of atmospheric temperature on signals generated by Orient 94.4 FM transmitter along some selected routes in Imo State, Nigeria.This research is deemed necessary because of the expectation from the government, the regulator, and consumers on the benefit that good signal strength within the research area would provide.

2. Study Location

Imo state is a state located in the southeastern part of Nigerian. Owerri is the capital of Imo state and her largest city. Imo state falls within longitude 6°50'E and 7°25'E, and

4°45'N and 7°15'N with an area of about 5, 100 sq km[9]. The state has a humid weather with substantial rainfall in most months, with a short period of the dry season. The average yearly temperature in Imo state is 26.4°C. The highest average temperature is recorded in March, at about 27.9°C and 25.0°C on average recorded in August isthe coldest month of the year [10].

Imo State Broadcasting Corporation (Orient 94.4FM) is an FM radio station band with her office located at Chief Achike Udenwa Avenue, New Owerri, Owerri municipal, Imo State, Nigeria. Orient 94.4FM wave radio band broadcasts news, sports, entertainment, music, songs etc. Orient FM currently transmits on a 4.2 kW transmitter and has an antenna which is about 1000feet high. Orient FM and Television broadcasting frequencies are 94.4 kHz (Radio) and 775.25 MHz (TV) respectively.

3. Literature Review

It has been shown that wireless sensor systems functioning in outdoors are open to changing weather conditions, which may result to serious dilapidation in the performances of the radio broadcasting system. Thus, it is important to discover the elements affecting radio link quality in order to lessen their effect and to adjust to erratic conditions [2].Precipitation and temperature do not significantly affect the transmission of TV signals. Although this does not cause a major problem, they have more effect on UHF when compared to VHF. However, for a long distance away from the transmitting station (greater than 25miles), weather may have an important effect on VHF signals. The effect is most likely due to natural phenomena along the path of transmission like a shed, the siding, a hill or cliff reversing the signals divergently when they are wet or cold. This may result to multi-path, where the signal from the transmitting station is lost by the reflected signal by some of these natural phenomena [11].

Temperature appears to be the superlative descriptive parameter for the variation of signal strength and has an adverse, rectilinear consequence on signal strength generally, whereas immense relative humidity may have some certain consequence, especially when the temperature is below 0oC. The connection between weather variables and signal strength differ with respect to radio station and connection. Although using frequency multiplicity will lessen these effects. Low transmitter power in most cases, leads to a minor in explicable disparity in signal strength received and consequently higher connection with the weather parameters [2].

Variation of weather arises because of changes in temperature which leads to the difference in density of the water and air and hence subsequently pressure gradients which excites the flow of those fluids (water and air). At the lower part of the atmosphere, weather parameters affect radio signal transmission at frequencies above 30MHz. The change that arises in the lower atmosphere relatively influences the efficiency of the radio transmission system and this is due to geometric dispersion of index of refractive in the atmosphere. Variation in Refractivity is accountable for several occurrences in the radio wave transmission such as elevation and range error in detector procurement, fading and refraction of electromagnetic waves, scintillation and ducting [12].

4. Methodology

The study to investigate the effect of atmospheric temperature on Orient 94.4 FM transmitter along some selected route in Imo state was carried out between the months of April and June, 2016. The equipment used to measure signal strength in the study areas is a constructed Signal Strength Meter (SSM). The modulated signal from the transmitting station is received by the signal strength meter through the antenna. The antenna used in this design is the ferrite coil antenna. The ferrite coil antenna is made up of turns of copper on a carbon. It has better reception in FM and AM but the reception is far much better in FM receivers. The signal strength monitor of the SSM is a meter attached to all the stages of the SSM so as to calculate the signal per stage and give out a particular value for the strength in decibel. The meter displays the relative strength of the signal on the channel tuned. It is used as a basis for signal comparison and in the monitoring of network. The atmospheric temperature was measured using Holo Ambient Temperature Pro {Thomas Otero (H3R3T1C)} along the routes of signal measurement. Measurements were taken in different months, on different days, and at a different time of the day and different temperature. The average results of these measurements were then taken and the data obtained from the measurements were tabulated and then subsequently plotted in a graph to ascertain the variation in signal strength along the different routes.

5. Result and Analysis

Investigations of the effect of atmospheric temperature on signal strength generated by Orient 94.4 FM were carried out in different months, on different days, at different temperature and at different times of the day. The values of the signal strength obtained from the field measurements were plotted against temperature to generate the corresponding signals strength summaries for each route where the investigations were carried out. The results of the findings were collected with respect to the routes where the investigation was done. Table 1 shows the characteristics of the different routes. Table 2 shows the characteristics of the transmitting station. Table 3 shows Signal strength variation with temperature along route A, B, and C at a distance of 20km from the transmitter while Table 4 shows Signal strength variation with temperature along route D, E, and F at a distance of 20km from the transmitter.

Table 1: Definition of the research's route

Routes	Pathway/Definition	Distance from transmitting station (Km)
A	Owerri – Onitsha Road	84.5
B	Owerri– Orlu Road	45.5
C	Owerri–Okigwe Road	61.3
D	Owerri – Aba Road	68.9
E	Owerri – Port Harcourt Road	94.5
F	Owerri – Nekede	23.6

Table 2: Characteristics of the transmitting station

Serial No.	Characteristics	Description
1	investigated station position	Long. 7.04˚& Lat.5.45˚
2	Base station's transmitting power	4.2 KW
3	Base station frequency (MHz)	94.4 MHz
4.	Transmitter in use	ZHC 10 KW
5	Height of transmitting mask	304.8 m
6	Elevation of propagating aerial	15.24 m
7	Propagating aerial gain	30.02 m
8	Height of receiving antenna	Inbuilt

Table 3: Signal strength variation with temperature along route A, B and C at a distance of 20km from the transmitter

Temperature (˚c)	Signal Strength (dB)		
	Route A	Route B	Route C
23	70	40	40
26	70	40	40
28	60	20	36
29	68	20	20
26	60	42	20
24	60	40	30

Table 4: Signal strength variation with temperature along route D, E, and F at a distance of 20km from the transmitter

Temperature (˚c)	Signal Strength (dB)		
	Route D	Route E	Route F
23	30	20	20
26	20	10	18
28	20	10	5
29	10	0	0
26	20	8	5
24	20	12	5

Analysis of the impact of temperature on signal strength generated by Orient FM transmitter

Fig. 1 shows the graph of signal strength variation with temperature along route A, B, and C at a distance of 20km from the transmitter. Why Fig. 2 A graph of signal strength variation with time along route D, E, and F at a distance of 20km from the transmitter.

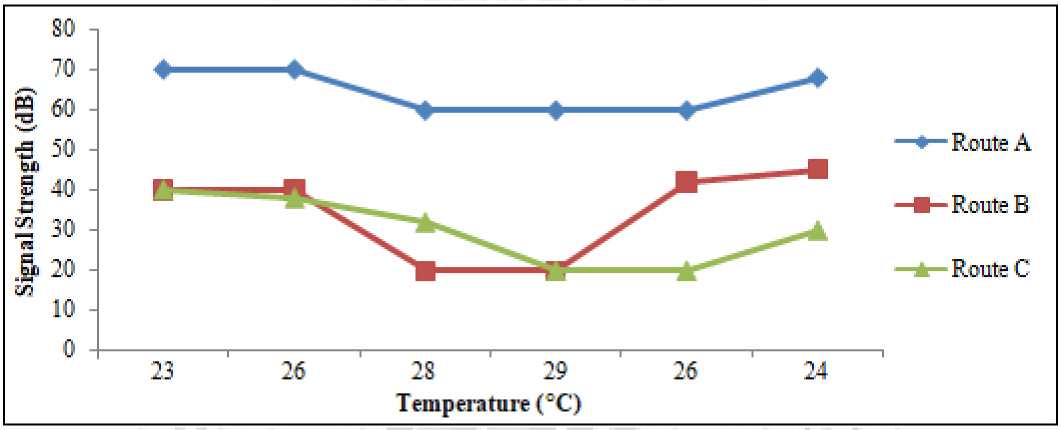

Figure 1: A graph of signal strength variation with temperature along route A, B and C at a distance of 20km from the transmitter.

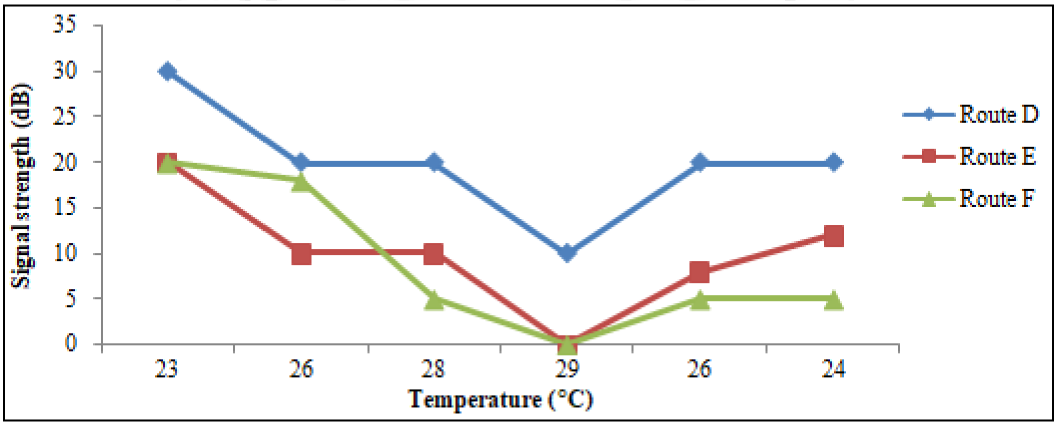

Figure 2: A graph of signal strength variation with time along route D, E and F at a distance of 20km from the transmitter

Figure 1 and Figure 2 give the variation of signal strength with temperature. It is shown that signal strength decreases with increase in temperature and vice versa. For instance, from Figure 1 along route B, the signal strength measured when the temperature was 23˚C was 40 dB at a distance of 20 km from the transmitter. The signal strength at the same distance of 20 km decreased to 20 dB at a temperature of 29˚C. But when the temperature dropped from 29˚C to 26˚C, the signal strength was discovered to have increased again to 42 dB. The signal strength further drops to 40 dB when the temperature drops to 24˚C from 26˚C. In Figure 2 the signal strength at route D dropped from 30 dB at a temperature of 23˚C to 20 dB at 26˚C. The signal further drops to 10 dB at a temperature of 29˚C and then increases again to 20dB when the temperature reduces to 26˚C. This shows that temperature affects the effective propagation and dissemination of signal. This same result was recorded in other routes of signal measurement.

The higher the temperature the less effective the signal strength will be. The signal strength becomes much higher at low temperatures. In other words, signal strength is inversely proportional to temperature; provided that transmission parameters such as the power of the transmitter, the height of transmitting antenna, transmitting antenna gain, the distance of the receiver from the transmitter remain constant.

6. Summary and Conclusion

Summary

Apart from factors which include both natural and human, like distance, temperature, time of broadcast, the power of transmission, the angle of transmission, multipath interference, co-channel and adjacent channel interference etc.; temperature can cause radio signal propagated to vary in some areas where they are transmitted. Temperature tends to have a negative effect on strength of the signal generated by frequency modulated transmitted signals. Troposphere scatters causes part of these radio signals to be refracted towards the earth at some distance within the normal line of sight. The result of this study shows that increase in temperature leads to degradation of the signal strength generated by Orient 94.4 FM.

Conclusion

The result of this research shows that the rise in atmospheric temperature will lead to a drop in strength of the signal generated by Orient 94.4 FM transmitter. Thus, it can be postulated that temperature varies inversely with the signal strength level provided the transmission parameters remain constant.

i.e., $T \propto \frac{1}{S}$

hence, $T = \frac{K}{S}$

where, T = Temperature in ^{o}C and S = Signal Strength in dB.

7. Suggestion for further study

This research focuses only on the effect of temperature on signal strength generated by frequency modulated transmitter, further research should thus aim at investigating the effect of other atmospheric parameters such as pressure, wind, humidity, and precipitation on FM transmitter, UHF or VHF signals.

8. Acknowledgement

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