EXPERIMENTAL STUDY ON THE IMPACT OF ATMOSPHERIC TEMPERATURE ON ULTRA HIGH FREQUENCY (UHF) RADIO COMMUNICATION FOR SUSTAINABLE DEVELOPMENT IN OYO, OYO STATE, NIGERIA

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A. L. Sheu

Department of Physics, Emmanuel Alayande College of Education, Oyo, Oyo State, Nigeria

sheuakeemlawal73@gmail.com

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Abstract: Radio signal strengths from Nigeria Television Authority (NTA) Oyo, UHF channel 37 Oyo State, Nigeria (7.83^0N, 3.95^0E) transmitted at 40.15 mdB and 606.25 MHz were measured simultaneously with atmospheric variables. The data logger digital field strength meter interfaced to the personal computer was employed for the field strength measurement. A self-designed inexpensive portable weather monitoring system was used for the measurements of weather conditions (atmospheric temperature, pressure, relative humidity and wind direction) to establish the influence of atmospheric temperature on radio signals. The sample data measurements were taken from the Administrative Block of Emmanuel Alayande College of Education, Oyo, Oyo State, Nigeria for over twenty four hours. The observations show that a significant change in the received UHF signal strength is caused by a substantial rise or fall in air temperature at Ku band in the study area which concludes that signal strength is inversely proportional to the air temperature, provided that other weather variables are perceived constant. Mathematically, $S\alpha \frac{1}{T} \Rightarrow ST = K$, where S and T represents UHF Signal Strength (dB) and Atmospheric Temperature (^{o}C) respectively and K is a constant. From the statistical data obtained, the curves of signal strength on temperature and its variations over the time are shown. The results would be highly esteemed to the administration of radio communication systems for enhancement and upgrading purposes.

Keywords: Atmospheric temperature, metrological components, NTA, radio signal, ultra-high frequency

Introduction

The transmitted UHF radio signals adopt chronological vicissitudes due to disparities in the atmospheric weather variables as confirmed by the prevailing researches. Radio signal propagation is affected by atmospheric pressure, temperature, relative humidity, wind speed and water vapor (primary atmospheric weather variables) in the troposphere (Yeeken & Michael, 2011). There is a steady disintegration in temperature within the troposphere due to increase in altitude. Radio communications operating within this sphere is hereby significantly impacted (Isikwue *et al*., 2013). There is continuous rise and fall of temperature at the tropopause and eventually levels out the temperature gradient.

The air refractivity performs a valuable role in the radio communications applications that use tropospheric radio wave propagation and majorly depends on the temperature, pressure and humidity of the atmosphere (Amajama, 2015). The air refractivity is directly proportional to the atmospheric temperature and to other climatological parameters concurrently (exclusive of wind) (Chima *et al*., 2018). The signal losses are caused by the condition of the atmosphere or meteorological state. Signal path losses are indispensable factors in the design of any radio communications system (Ukhurebor *et al*., 2018). Signal path loss is basically expressed as the degradation in strength of a signal as it travels through a particular region or medium (Akinwumi *et al*., 2017). The free space path losses, absorption losses, diffraction losses, multipath, terrain, buildings, vegetation and the atmosphere are some of the factors that may cause path losses during signal path propagation (Agbo *et al*., 2013). The atmospheric temperature, pressure, humidity, wind speed and direction are the major elements of the atmosphere that constitute the weather (Aremu *et al*., 2018).

The air temperature is the measure of temperature at different levels of earth's atmosphere and expressed in degree Celsius (^{o}C), it has a slight significant negative effect on signal strength as revealed by some researchers (Ayantunji *et al*., 2018). The focus of this research is to investigate the impact of the atmospheric temperature from Administrative Block of Emmanuel Alayande College of Education, Oyo, Oyo State, Nigeria for a period of one year (January to December, 2020) using a self-designed cost effective portable weather monitoring systems. The results would be valuable to the administration of radio communication systems for enrichment and improvement purposes.

Materials and Methods

The measuring instrument applied in this research is a data logger digital field strength meter interfaced to the personal computer for the field strength measurement. A self-designed inexpensive portable weather monitoring system was used for the measurements of the various atmospheric weather variables used for this study. The measuring method is fixed by placing the monitoring system above ground level for the measurements and micro SD card storage of the atmospheric air temperature at the Administrative Block of Emmanuel Alayande College of Education, Oyo, Oyo State, Nigeria.

The main objective of the study was to obtain statistical data of signal strengths and meteorological components in the College Administrative Block to determine the impact of the atmospheric temperature on radio wave signal. The measurements of the atmospheric temperature were made for a period of one year (January to December, 2020). The received signal was measured only on the downlink and the receiver antenna was adjusted until the best obtainable result of signal strength was captured on the micro SD card storage before recording.

Results and Discussion

The result of the experiment has been analyzed to substantiate the impact of atmospheric temperature on Ultra-high Frequency (UHF) radio signal in Oyo, Oyo State, Southwest, Nigeria. From the statistical data obtained, the curves of signal strength on temperature, humidity, pressure and wind speed are shown in Table 1 and Fig. 1. The observations show that a significant change in the received UHF signal is caused by a substantial rise or fall in air temperature which concludes that signal strength is inversely proportional to temperature. Temperature is observed at the troposphere to decline swiftly with altitude 10 degrees Celsius per kilometer rate.

Table 1: Sample data of signal strength and weather variables in Oyo, Oyo State, Nigeria

Time (hr)	Signal Strength (dBµV)	Temperature (^{0}C)	Humidity (%)	Wind Direction (MpH)	Pressure hpa
00.30	78.50	30.0	79.0	1.03	975.7
01.00	77.10	29.1	78.0	1.04	976.0
01.30	76.00	28.0	78.0	1.03	975.7
02.00	76.50	28.1	78.0	1.03	975.9
02.30	76.10	29.0	79.0	1.02	975.7
03.00	76.50	30.0	78.0	1.03	975.6
03.30	76.80	30.0	78.0	1.03	975.5
04.00	73.60	28.1	78.0	1.04	975.7
04.30	76.00	29.0	78.0	1.03	975.4
05.00	76.15	29.0	77.0	1.02	975.7

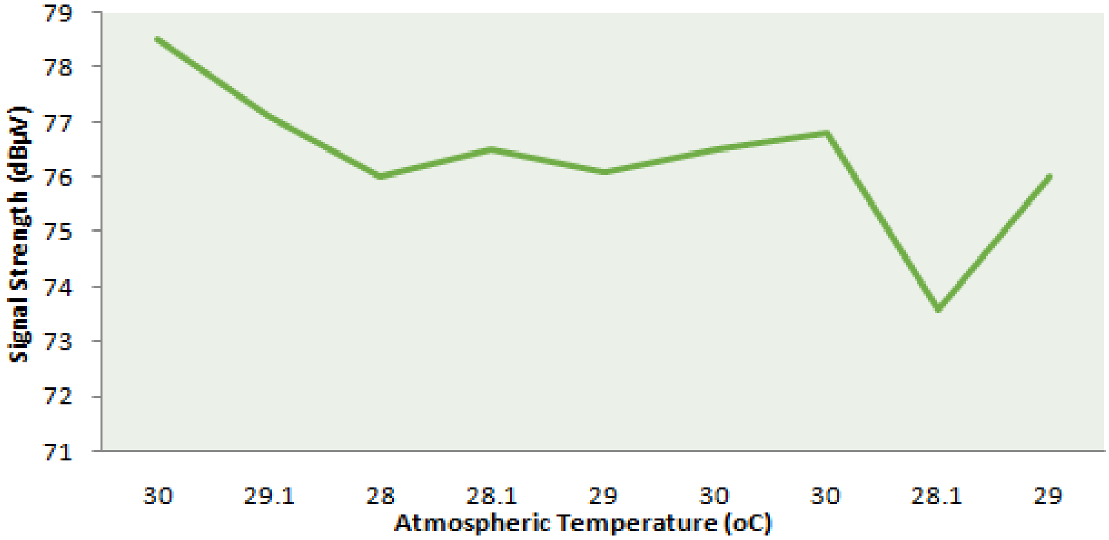

Fig. 1: Relationship between signal strength (dBµV) and atmospheric temperature (°C)

The sample data from the study showing the Signal strength (dBµV) at diverse atmospheric temperature, constant relative humidity of 78%, near uniform atmospheric pressure of 975.7.8(+0.02) in hpa and relative constant wind speed and direction of 1.03 MpH is shown in the Table 1. In this study, the extent of how certain factors affect radio communication is challenging in the UHF range with many atmospheric variables interacting with one another due to disorganized system of weather. It is revealed from the research that signal strength decreased with a slight rise in temperature. Hence, the higher the temperature, the lower the signal strength. The correlation between the two parameters mathematically is -0.78 in value. According to the study, the UHF signal strength is inversely proportional to the air temperature, provided that other weather variables (atmospheric pressure, relative humidity, wind speed and direction) are perceived constant. Mathematically, $S\alpha\frac{1}{T}\Rightarrow ST=K$, where S and T represents UHF Signal Strength (dB) and Atmospheric Temperature (°C) respectively and K is a constant. This research validated that if performance degradation induced by frequency shifts and thermal transceiver noise through crystal accuracy is to be forestalled, atmospheric temperature variation is indispensable. A change in UHF signal receptions over diverse distances during varying environmental conditions is convincingly established in this study.

Summary, Conclusion and Recommendation

Summary

The results obtained in this study revealed the characterization of UHF radio signal and the meteorological components to examine the influence of the atmospheric temperature on propagating radio signal. Fallouts from the research shows that increase in temperature results in the degradation of signal strength, provided other atmospheric variables remain constant. More enthusiastically than applying prevailing link margin invented from other regions data evaluation, the efficient link margin and budget of radio transmission can be developed with this result for the study area.

Conclusion

In conclusion, it is observed from the Administrative Block of Emmanuel Alayande College of Education, Oyo, Oyo State, Nigeria that there is inverse relationship between the atmospheric temperature and radio signal propagation in this region, provided that other weather conditions remained constant.

Recommendation

The research is limited to the impact of atmospheric temperature on the UHF radio signal in Oyo, Oyo State, Nigeria. Further researches are recommended to consider other meteorological components in this and other regions with adoption of different approaches for verification and confirmation of this study on radio signal propagation.

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