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Impact of Atmospheric Temperature on (UHF) Radio Signal

Joseph Amajama

Department of Physics, University of Calabar – Nigeria, joeamajama2014@yahoo.com, +2347036357493

Abstract— Radio signal strengths from Cross River State Broadcasting Co-operation Television (CRBC-TV), ($4^0$57'54.7"N, $8^0$19'43.7"E) transmitted at 35mdB and 519.25 MHz (UHF) were measured using a Cable TV analyzer in a residence along Etta-abgor, Calabar ($4^0$57'31.7"N, $8^0$20'49.7"E) simultaneously with the meteorological components (weather parameters): atmospheric temperature, atmospheric pressure, relative humidity and wind speed and direction to ascertain the impact of atmospheric temperature on radio signals. The meteorological components with signal strength were measured half hourly from the residence for over 24 hrs to draw a justifiable inference on the impact of the atmospheric temperature on the radio signal. Results indicated that radio signal strength is inversely proportional to atmospheric temperature; provided that, other measured metrological components were observed constant, including the wind speed and direction. The correlation of the signal strength and atmospheric temperature was r = -0.93 and the equation S =K/T at constant atmospheric pressure, relative humidity and wind speed and direction was postulated, where S, T and K are Signal strength, Atmospheric temperature and Constant respectively.

Keywords— Metrological components, Atmospheric temperature, Radio Signal, Signal strength, Ultra High Frequency (UHF).

INTRODUCTION

Generally, with increasing altitude there is a regular decline in temperature within the troposphere. Consequently, there is a readily distinguishing impact on some "radio propagation modes" and radio-communications that take place in this sphere [11]. Until the "tropopause" is attained there is a continuous decline in temperature in the troposphere. Here (at the tropopause) the temperature starts to rise and levels out the temperature gradient. The mercury is about – 50 ^oC at this point [11].

The air refractivity of the troposphere performs a beneficial purpose in the radio communications applications that use "tropospheric radio wave propagation". The air refractivity depends on the temperature, pressure and humidity of the atmosphere [3]. The atmospheric temperature has an effect on the air refractivity. The air refractivity is directly proportional to the atmospheric temperature and simultaneously other meteorological parameters (exclusive of wind) [15].

The atmospheric condition (weather) has a significant effect on signal [13] [7]. The condition of the atmosphere or meteorological state can cause signal losses. Signal path losses are an essential factor in the plan of any radio communications system [12]. Basically, signal path loss is the degradation in strength of a signal as it travels through a particular region or medium [4] [12].

The following are some of the factors that may cause path losses during propagation. They are: free space path losses, absorption losses, diffraction losses, multipath, terrain, buildings and vegetations and the atmosphere [4]. The major elements of the atmosphere that constitute the weather are the atmospheric temperature, pressure, humidity and wind speed and direction. The atmospheric temperature is a measure of the average kinetic energy of air molecules at 2 m (6 feet) above the surface [8]. Atmospheric temperature has a slight negative effect on signal from earlier studies [5].

This research work focuses its search light on the impact of the atmospheric temperature from a residence at Etta-agbor in the Calabar metropolis on radio signal of about 519.25 MHz and 35mdB which is the frequency and signal strength of transmission respectively of the Cross River Broadcasting Corporation Television (CRBC-TV), Calabar, Cross River State, Nigeria.

To score the goal of this work, signal strength evaluations in the Etta-agbor residence were made simultaneously with the meteorological components (atmospheric temperature and pressure, relative humidity and wind speed and direction) to investigate the atmospheric temperature bearing on radio signal.

METHODOLOGY

The Radio Wave Experiments

The campaign was carried out in a residential area (Etta-abgor) within the Calabar metropolis in Cross River State, Nigeria. The main object of the experiments was to obtain statistical data of signal strengths and meteorological components in the aforementioned residential area to determine the impact of the atmospheric temperature on radio wave signal. Signal strengths were obtained every 30 mins at the residential area for over 24 hrs and simultaneously, the meteorological components: atmospheric temperature and pressure and relative humidity and wind direction and speed were recorded to probe the impact of the atmospheric temperature on the signal. The measurement of the signal strength was made using the Digital Community – Access (Cable) Television (CATV) analyzer with 24 channels, spectrum 46 - 870 MHz, connected to a domestic receiver antenna of height 4.23 m.

To be able to reach a justifiable conclusion on the impact of the atmospheric temperature on the signal, the dependence of the signal strength on relevant parameters was analyzed. These relevant parameters were the: atmospheric temperature and pressure, relative humidity and the wind speed and direction. 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 cable analyzer before recording.

Relevant Properties of the Digital CATV Analyzer

Digital Community – Access (Cable) Television (CATV) analyzer with 24 channel spectrum, model "DLM3-T", operates over a frequency range of 5 - 65 MHz for lower band (mobile transmit, base receive) and 46 - 870 MHz for upper band (base transmit, mobile receive). The channel spacing is 8 MHz. It is specially designed to provide a band of the free "off-air channels" and provides a relative reading of signal strength that is aided by a unidirectional antenna in alignment. It can measure signal levels of 0 - 100 mdB and has an inbuilt rechargeable batteries that can provide power to an "antenna pre-amp" to accurately give a set-up location. Its maximum sensitivity is approximately -100 mdB. TV images and test data are displayed simultaneously, efficiently and conveniently [2].

Sites Descriptions

The site ($4^0$57'31.7"N, $8^0$20'49.7"E) where the weather was under study to ascertain the impact of the atmospheric temperature on the signal strength was a residential area in the Calabar metropolis – Nigeria. It is at Atta-agbor. There are scanty trees with predominantly low height buildings of about 2 m to 3 m.

Measurement Method

To determine the impact of the atmospheric temperature on radio signal, the CATV analyzer was stationed in an apartment and the 4.23 m high antenna was connected to it and mounted outside. The atmospheric temperature and pressure, relative humidity and the wind speed and direction and corresponding signal strength were taken every 30 mins for over 24 hrs.

Sampling with the CATV analyzer

Measurements with the digital CATV analyzer being time dependent were made approximately every sixty seconds (60 s). The average signal strength value (mean of minimum and maximum reading) was recorded when the images were sharpest.

RESULT AND ANALYSIS

The result of the experiments is analyzed below. To determine the impact of the atmospheric temperature on radio signals, some data or measurements extracted/excepted from the whole were used to determine the impact of mentioned parameter above on the signal strength, through the curve that was produced.

Analysis of the impact of atmospheric temperature on radio signal strength

The four meteorological components that govern our weather are the atmospheric temperature, atmospheric pressure, relative humidity and wind speed and direction.

Fig. 1 below shows the graphical relationship between signal strength and atmospheric temperature.

TABLE 1

Measurement of Signal strength (mdB) at different atmospheric temperature, at uniform relative humidity of 94%, near uniform atmospheric pressure of 29.92($\pm$0.02) inHg and uniform wind speed and direction of 0mph NA

Atmospheric temperature (^{0}F)	**Signal strength (mdB)**	**Relative humidity (%)**	**Atmospheric pressure (inHg)**	**Wind (mph) N**	**Time (hour)**
77.0	9.4	94	29.91	0 NA	22:30
78.5	9.0	94	29.94	0 NA	8:00
78.0	9.3	94	29.94	0 NA	8:30
79.5	7.8	94	29.94	0 NA	11:30
79.0	8.0	94	29.94	0 NA	12:00

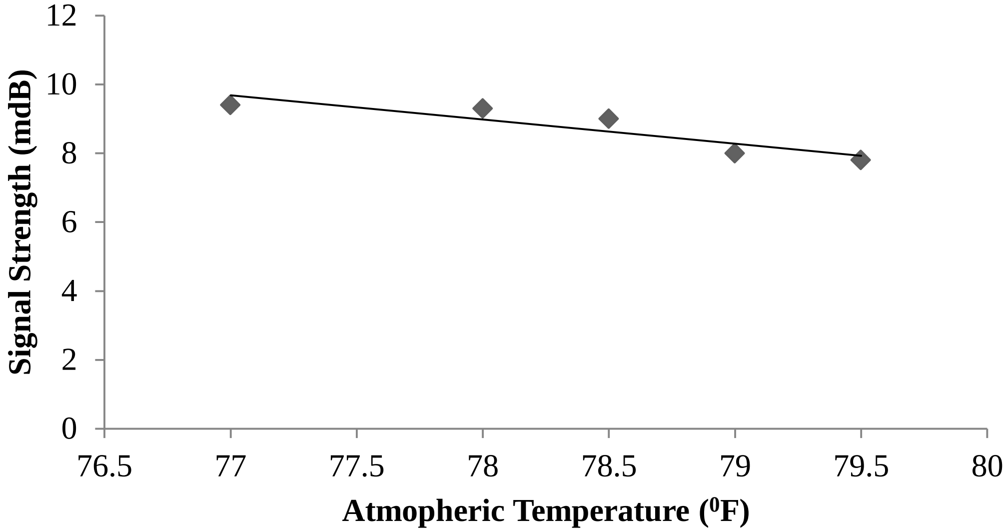

Fig. 1. Relationship between signal strength (mdB) and atmospheric temperature (^{0}F), at uniform atmospheric pressure of 29.92 (+0.02) inHg, uniform relative humidity of 94 % and uniform wind speed and direction of 0 mph NA.

Fig. 1 shows the relationship between signal strength and atmospheric temperature, at a uniform humidity of 94 %, uniform atmospheric pressure of 29.92 (+ 0.02) inHg and uniform wind speed and direction of 0 mph NA. The signal strength decreased with a slight rise in temperature. Mathematically, the correlation between the two parameters is -0.94 in value. Hence, the higher the temperature: the lower the signal strength. In other words, the signal strength is inversely proportional to temperature, provided that other meteorological components, atmospheric pressure, relative humidity and wind speed and direction are observed constant.

If S (dB) and T (^{o}F) symbolize Signal strength and Atmospheric temperature respectively, it can be postulated that $S \propto \frac{1}{T}$ or ST=K (i.e. $S_1T_1=S_2T_2$ where S_1T_1 and S_2T_2 represent initial and final state conditions) at the same atmospheric temperature and pressure, relative humidity and wind direction and speed, where K is a constant.

SUMARRY, CONCLUSION AND RECOMMENDATION

Summary

In this work, experiments have been carried out to characterize the propagation of radio signals through the atmosphere to determine the impact of the atmospheric temperature on propagating radio signal.

Results from the meteorological components at the residence in Etta-agbor: atmospheric temperature and pressure, relative humidity, wind speed and direction revealed that; increase in temperature results in the degradation of signal strength, observing other meteorological components constant. The correlation between the signal strength and temperature was found to be r = -0.94. The phenomenon that explains this is that there is a collision between increasing raining particles of light from the sun as temperature increases with the radio signals, this attenuates the signal strength. This is true since electromagnetic waves which radio signal (radio wave) is a member share the same properties and are reflected or diffracted or refracted when they encounter an obstacle [1] [6] [9] [10] [14].

Conclusion

In conclusion, it was observed from the residential area in Etta-agbor, Calabar-Nigeria, that the atmospheric temperature was inversely proportional to the signal strength, provided that the meteorological components: atmospheric temperature and pressure and relative humidity were observed constant including wind speed and direction. Hence ST = K at same atmospheric pressure, relative humidity and wind speed and direction; where S = Signal strength, T = Atmospheric temperature and K = Constant.

Recommendation

Since the investigation the impact of the atmospheric temperature with this new methodology, on radio signal is a pioneering or ground breaking research, other students or researchers should be encouraged to further investigate this postulations with sufficient data in different climates to verify the claim and ascertain the impact of other meteorological components on radio signal.

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