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The Effects of Atmospheric Temperature and Wind Speed on Uhf Radio Signal; a Case Study of ESUT Community and Its Environs in Enugu State

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Abstract: *Radio Signal Strengths From Automatic Weather Station Signal Strength Meter(AWSSSM) In The Department Of Industrial Physics ESUT, Longitude 7.54˚ And Latitude 6.31˚ Transmitted At 11.7-12.7Ghz Ku Band Signal Which Was Converted To 950-2150mhz Simultaneously With The Meteorological Components (Weather Parameters): Temperature, Pressure, Relative Humidity And Wind Speed And Direction To Ascertain The Impact Of Atmospheric Temperature And Wind Speed On UHF Radio Signals In ESUT Community And Its Environ. We Downloaded Our Data From The AWSSSM And Were Statistically Analyzed. It Was Observed That Temperature Inversion In The Tropospheric Layer Causes A Ducting Effect Which Affects Radio Signals. Consequently, The Speed Of Wind Was Found To Have An Effect On The Refracting (Bending) Capability Of The Wave. This Finding Thus Indicates That A Slight Change In These Parameters Causes A Considerable Effect On The Signal Strength. The Results Obtained During The Analysis Between UHF Radio Signal In The Troposphere And The Atmospheric Parameters (Temperature And Wind Speed) Shows That The Variation Of This Parameters Affects Radio Propagation In The Study Area.*

Key words*. Atmospheric Temperature, Radio Signal, Signal Strength, Ultra High Frequency (UHF).*

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I. Introduction

Radio Wave Is One Of The Seven Components Of The Electromagnetic Spectrum And Comprises Of Frequency Ranges Called Bands. These Ranges Are The Ultra-High Frequency (UHF), Very Low Frequency (VLF), Ultra Low Frequency (ULF) And Many Others. The IEEE Defines The Ultra-High Frequency Radar Band As Frequency Between 300MHZ And 1GZ. The Ultra-High Frequency Refers To Band Of Electromagnetic Radiation With A Radio Frequency Range Of 300MHZ To 3GHZ (300MGZ) And A Wavelength Of 1m To 1dm.Ultrahigh Frequencies Are Weakly Reflected By Ionized Layers Of The Upper Atmosphere Thus Unlike Other Radio Waves Spectrums, They Bend Very Little Around The Curvature Of The Earth And Are Easily Obstructed. Radio Waves In The UHF Band Travel Almost Entirely By Line-Of-Light Propagation (LOS) And Ground Reflection Unlike The High Frequency (HF) And Very High Frequency (VHF) Where There Is Little Or No Reflection From The Ionosphere (Seybold And John, 2005). Major Telecommunication Providers Have Deployed Voice And Data Cellular Networks In The UHF Range And The Network Is Distributed Over Large Areas Called Cells, Each Having At Least One Fixed Location Transceiver Or Base Station. These Base Stations Provide The Cell With The Network Coverage Which Can Be Used For The Transmission Of Voice, Data And Others. A Cell Generally Uses A Different Set Of Frequencies From The Neighboring Cells So As To Avoid Interference And Hence Good Quality Of Service Is Guaranteed (Jens Zander Et Al., 2016). This Cellular Network Provides Signal Strength To A Mobile Phone And These Strengths Vary With Environmental And Atmospheric Factors. As We Know, Cellular Signals Are Designed In A Way To Provide Resistance To Multipath Reception Which Is Likely Caused By High Terrains And Buildings. A Predominant Factor Affecting Cellular Signal Strength Is The Weather Parameters Especially Temperature And Wind. Wireless Communication Uses Radio Propagation In Order To Achieve Good Quality Of Service And Minimal Variation In Signal Is Required Otherwise Fading In Receiver (Such As Drop Cells) Can Be Observed.
Recent Studies Have Shown That The Transmitted Radio Signals May Go Through Spatial And Temporal Changes Due To Variations In The Atmospheric Conditions As Well As Environmental Factors (Gunasheka, Et Al., 2006). These Variations Take Place In The Troposphere And It Is Due To Refractivity Changes In This Region That Causes These Changes. It Has Been Proved That The Path Bending Of Electromagnetic Waves Due To Inhomogeneous Spatial Distribution Of The Refractive Index Of Air Causes Adverse Effects Such As Diffraction On The Terrain Obstacles Or The So Called Radio Holes (Lavergent And Sylvain, 2000). Atmospheric Refractivity Is Dependent On Physical Parameters Of Air Such As Temperature, Pressure, Relative

Humidity, Wind And Precipitation. It Is Observed That At The Region Of The Troposphere, Temperature Decreases Rapidly With Altitude At A Rate Approximately 10 Degrees Celsius Per Kilometer (Hall, 1979; Picquernard, 1974). Wind Is Observed In Troposphere When There Is A Resultant Charge In The Atmospheric Pressure Which Results In The Movement Of Air From A Lower To A Higher Region Causing Winds Of Various Speeds. Thus In Order To Improve And Upgrade Network So As To Minimize The Occurrence Of Dropped Calls, Access Failures And To Know The amount of fading expected at a given period of time in this environment, weather parameter measurements are taken. This project research evaluates the relationship between temporal signal strength fluctuations caused by wind and temperature using the data obtained from the Automatic Weather Station and Signal Strength Meter(AWSSSM) in Enugu State University of Science and Technology (ESUT) for a period of five months.

II. Materials and Method

Sources of Data

The Data Used For This Work Was Downloaded From Automatic Weather Station And Signal Strength Meter Installed (AWSSSM) In The Department Of Industrial Physics ESUT From A Signal Receiving System, Which Was Set Up By Connecting A High Gain Ultra-High Frequency Antenna And Spectrum Analyzer As Shown Below.

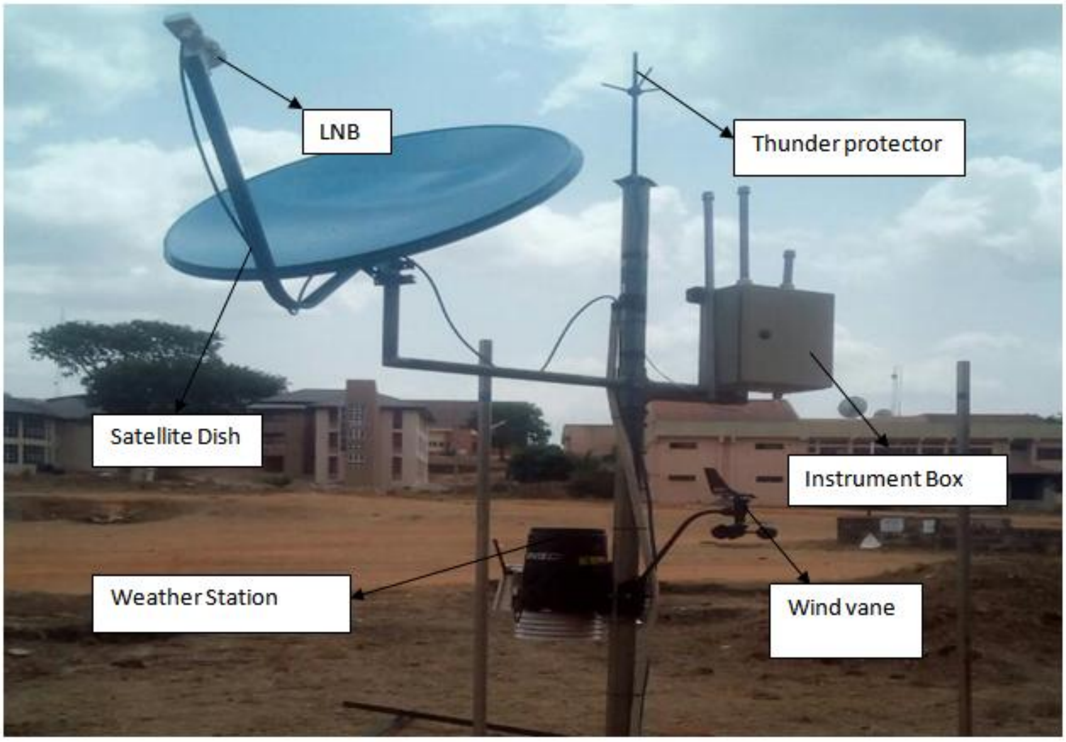
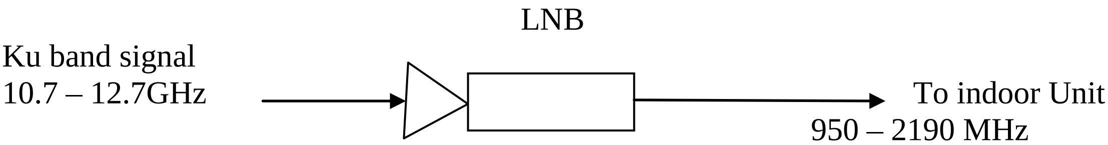


Figure 1 showingthe pictorial representation of the AWSSSM

Descriptions Of The AWSSSM

The Satellite Dish Is Focused On ASTRA1R 15.2^{0}E Located At The Geostationary Orbit Or Clark Orbit. The Dish Concentrates The Signal At Low Noise Block (LNB). The LNB Is A Universal Type Receiving 10.7 Ghz – 12.6ghz (Ku Band), It Then Down Convert It To Signal Between 950 MHZ – 2150mhz. The Major Reason For The Conversion Is That The 10.7ghz – 12.6ghz Signal Cannot Be Transmitted Through Coaxial Cable (Because Of Attenuation). Therefore, A Lower Frequency Was Chosen For The Transmission Into The Internal Unit Via Cable.



Instrument Box contains the followings;

i. 3 Gsm Modems For Network Signals
ii. Gps Module
iii. 2.4 Ghz Transceiver To Translate Processed Signal Into The Indoor Network Signal Analyzer.
iv. The Gsm Modules Converted The Gsm Network Around Depending On The (Sim Card Used) And Capture The Network Strength.
v. The Gps Detects The Longitude And Latitude Of The Location. A Central Processor Then Collates These Into And Then Sends Then To The Indoor Unit Via A 2.4 Ghz Transceiver.

The Indoor System Consists Of

i. Power Supply Phantom Power To The Lnb. Lnb Is An Amplifier System And Needs Power To Operate, The Power Is Sent To It From The Indoor System Via The Coaxial Cable. It Also Sends Its Own Signal To The Indoor Unit Via The Same Cable.
ii. Rf Power Detector To Detect The Power Of The Signal Coming To The Lnb In Dbm.
iii. Processor Connects With The Power Detector And Sends The Detected Power To The Pc.

The Logger Software On The Pc Was Written With Visual Studio 12.0 And It Accepts Connection From The Two Instrumentation System Displays Them As Graphs.

III. Methods

The Experiment Was Carried Out In The AWSSSM And The Main Purpose Was To Determine The Effect Of Temperature And Wind Speed) On Signal Strength, By Connecting High Gain UHF Antenna Transmitted At 519MHZ And Ku Band Signal Of 11.7- 12.7GZ With A Global Positioning System(GPS) Of Longitude 7.5, Latitude 6.3 Spectrum Analyzer Coupled With A Laptop System. The Measurement Was Taken For A Period Of 5 Months Starting From The Month Of April To August 2017. The Signal Strength In The KU Band Spectrum Was Obtained Every Two (2) Seconds Daily And Simultaneously The Meteorological Components (Temperature And Wind Speed) Were Also Observed. The Software Automatically Measures The Signal Strength In Decibel Meter (Dbm).

IV. Results

The result of the experiment has been analyzed to determine the effect of atmospheric temperature and wind speed on ultra-high frequency (UHF) radio signal. The curves of signal strength on temperature and wind speed were obtained from the data gotten from the Automatic Weather Station for a period of five months as shown In figures 2, 3, 4,5 and 6, it was clearly observed that a considerable increase or decrease in temperature causes a significant change in the received signal. Also in figures 7, 8, 9 ,10 and 11 shows that wind speed has a little impact on signal strengths.

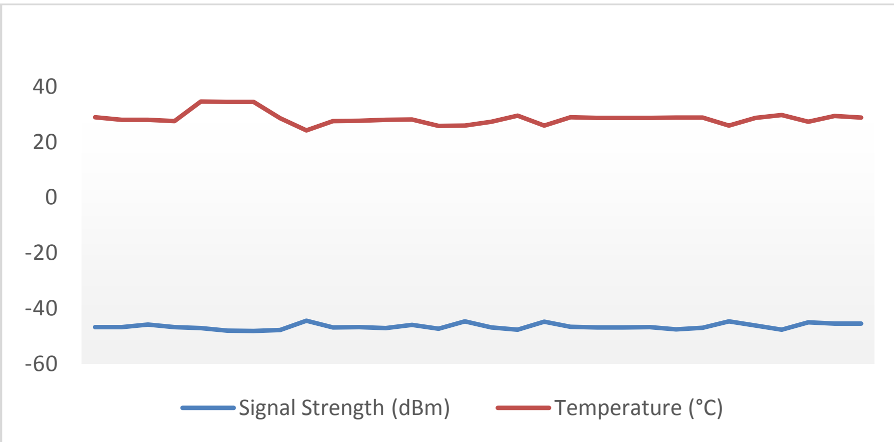


Figure 2. Curve of Signal Strength Versus Temperature for The Month of April

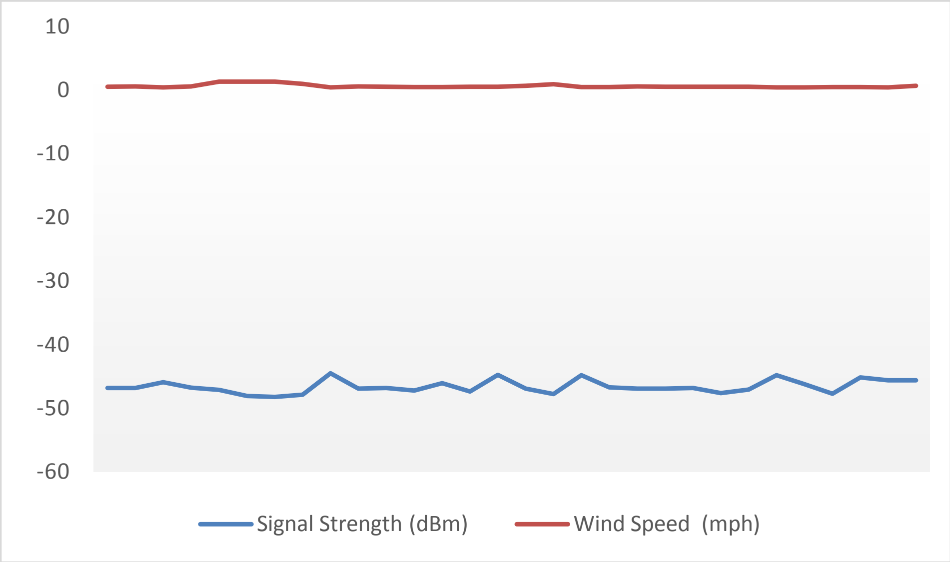


Figure 3. Signal Strength Versus Wind Speed For The Month Of April

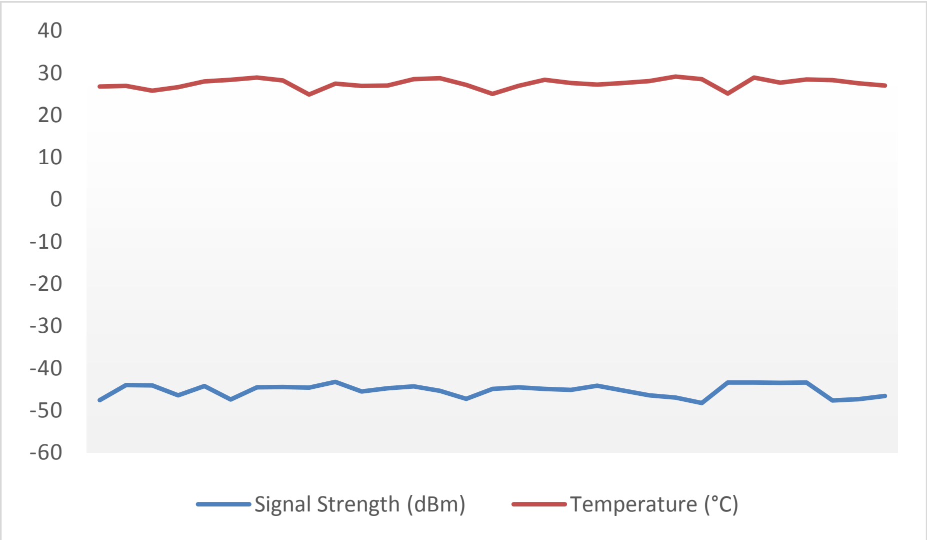


Figure 4. Graph Of Signal Strength Versus Temperature For May

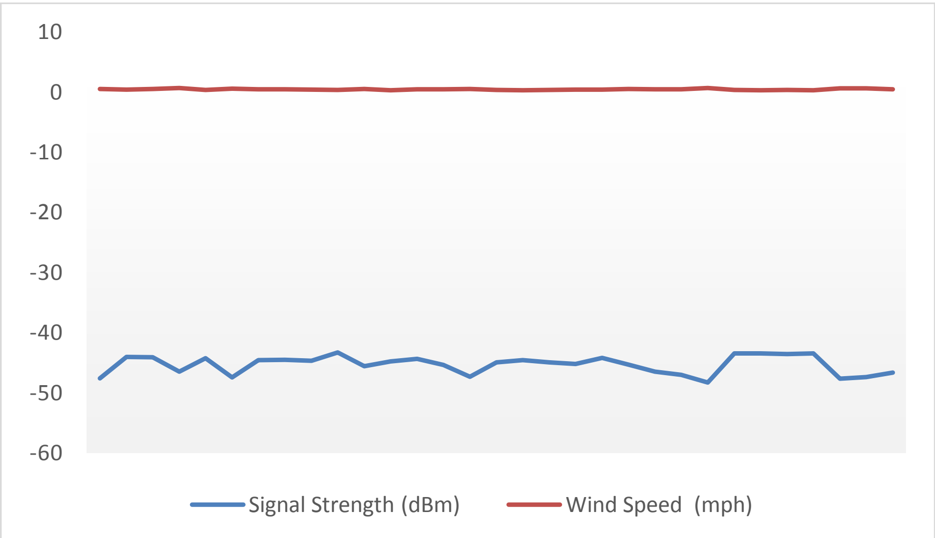


Figure 5. Signal Strength Versus Wind Speed For May

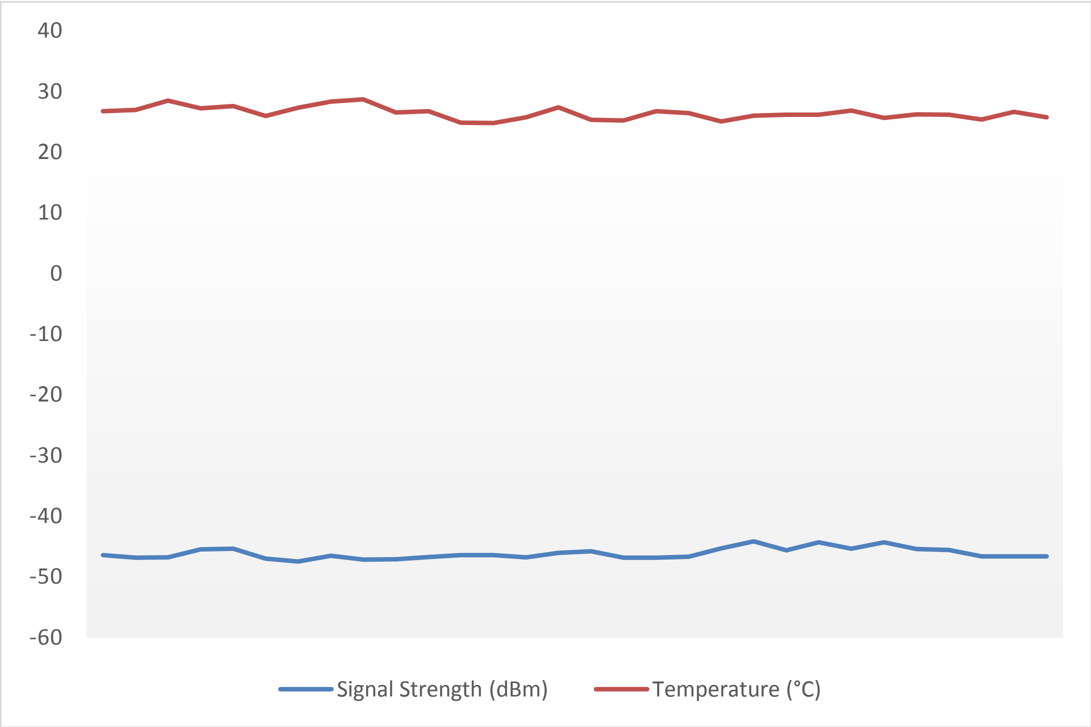


Figure 6. Signal Strength Versus Temperature For June

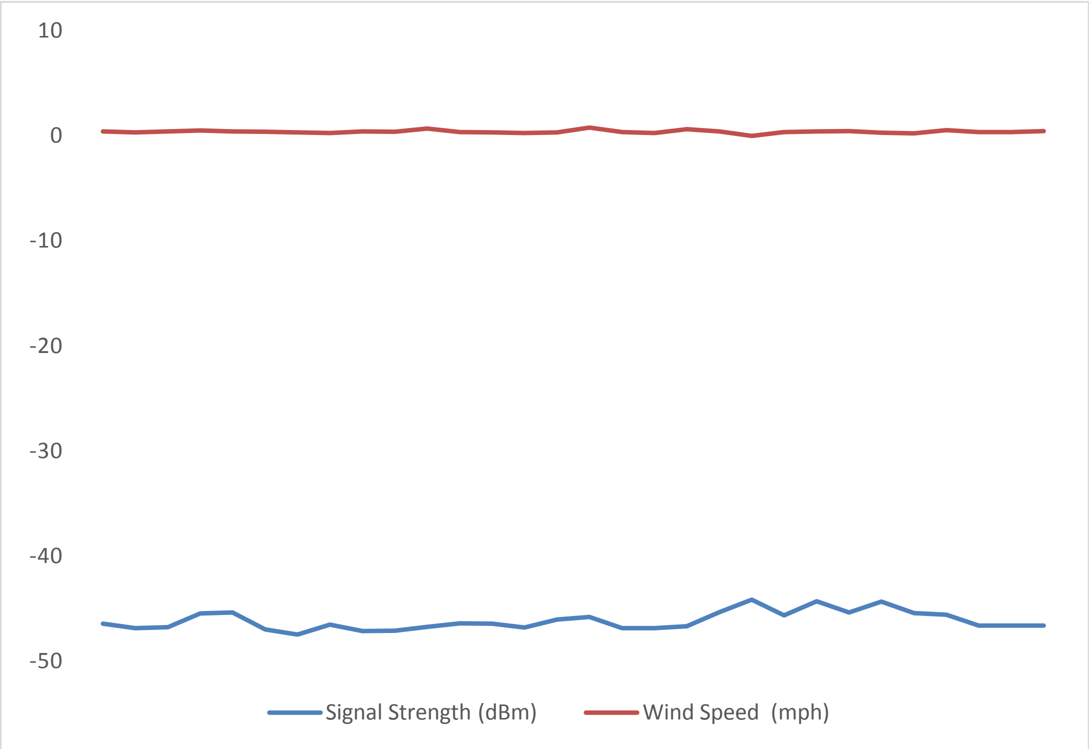


Figure 7. Signal Strength Versus Wind Speed For June

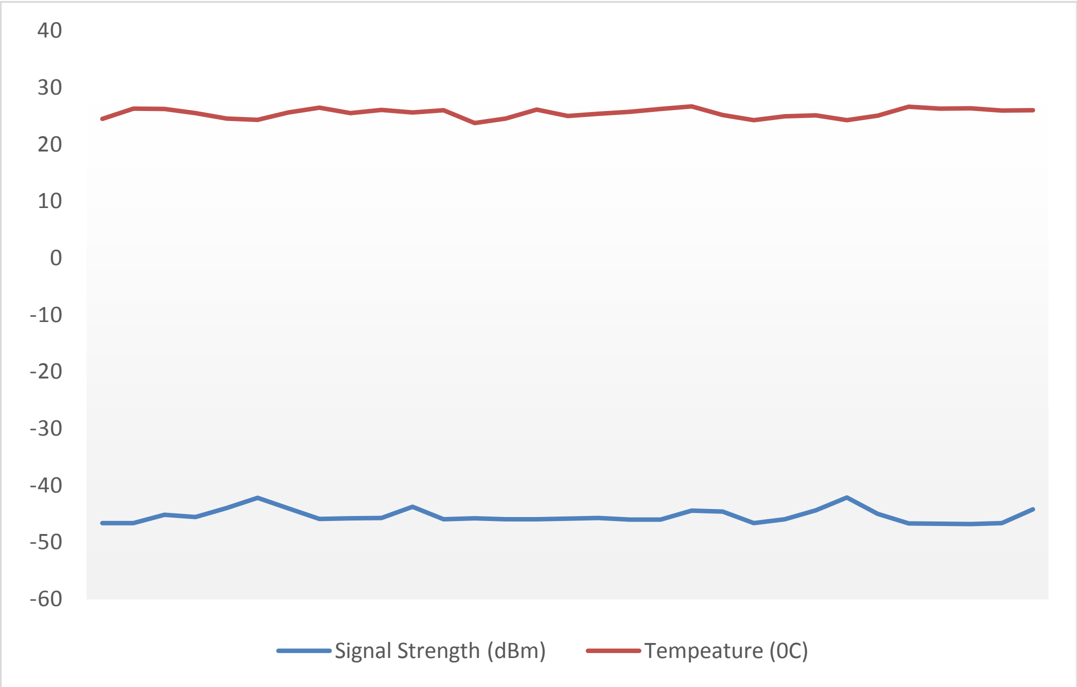


Figure 8 Signal Strength versus Temperature for July

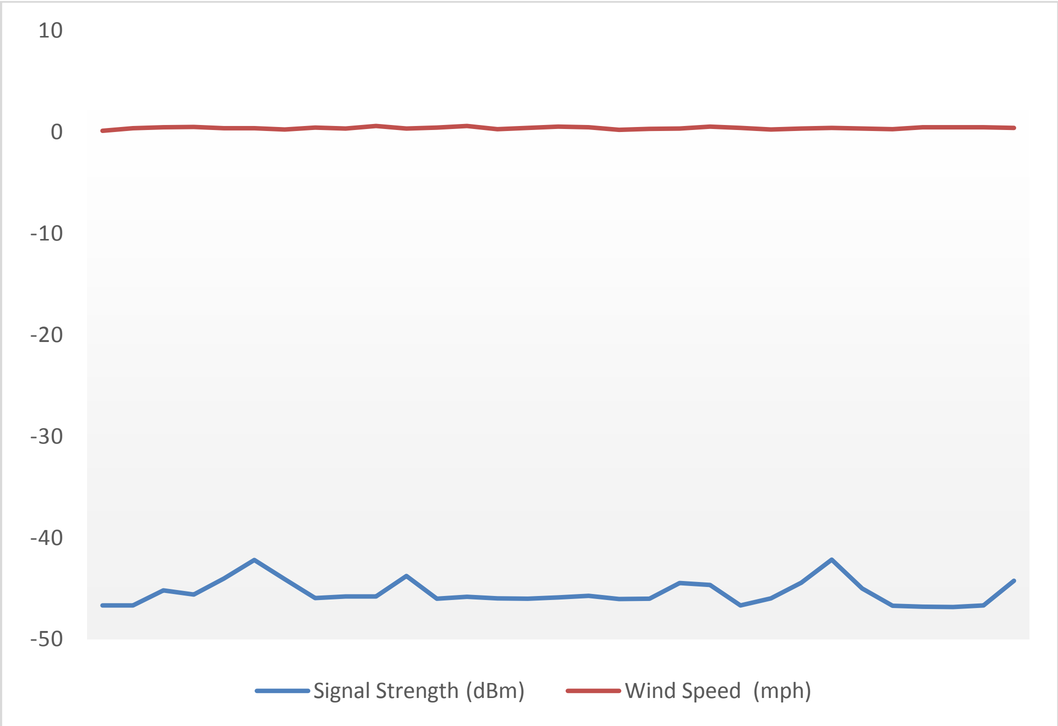


Figure 9. Signal Strength Versus Wind Speed For July

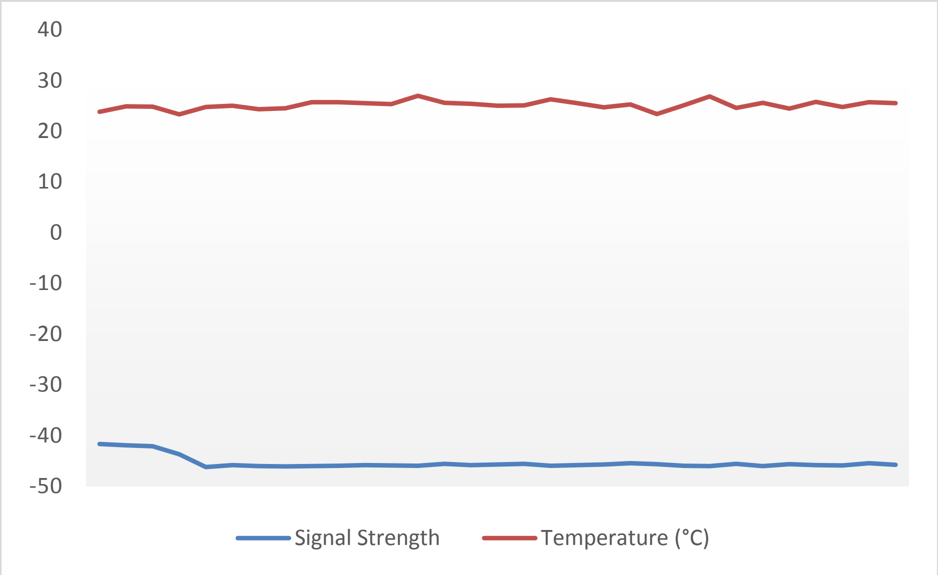


Figure 10. Signal Strength Versus Temperature

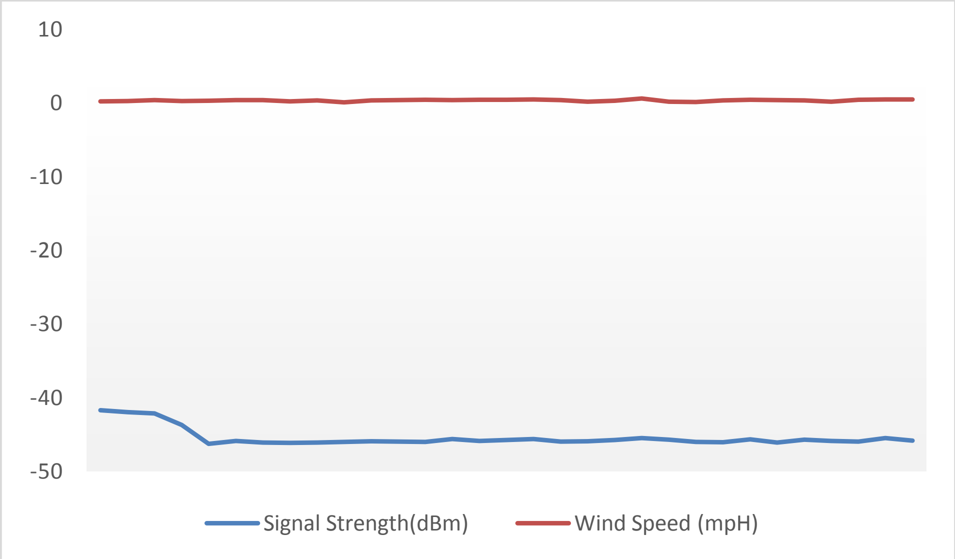


Figure 11. Signal Strength Versus Wind Speed for the Month of August

4.2 Discussion

The fact that weather is such a chaotic system with many variables interacting with one another makes it challenging to study how certain factors influences Radio communication in the UHF range. Temperature and wind speed were observed to have effect on the signal strength in contrast to some past research which introduces some discrepancies on them. Work by Holland et al., (2006), concludes that temperature has no impact on received signals. Their view is also shared by Anastasi et al., (2004), who do not observe a change in packet receptions over different distances during varying environmental conditions. Their findings were contradicted by Boano et al., (2010) and Bannister et al., (2008) who specifically show how higher temperature can reduce received signal strength on a sensor node. They argued that change in temperature affects crystal accuracy which induces frequency shifts and thermal transceiver noise that may degrade performance. Also, according to recent research by Joseph Amajama (2016), signal was found to decrease with a slight rise in temperature and he concluded that signal strength is inversely proportional to temperature. As we know, temperature decreases with height in the troposphere but due to ducting caused by inversion of temperature in this region of the atmosphere, the reverse is the case. During propagation of ducting, when a signal encounters a rise in temperature instead of the normal decrease, the signals are bent due to change in the refractive index of the atmosphere at the boundary between air masses of different temperatures and humidity. Using a simple analogy, it can be said that the denser air at ground level slows the wave front a little more than does the rare upper air, imparting a downward curve to the wave travel, this leads to the unanswered questions been asked by many researchers whether the wind speed in a medium through which radio waves travel affect radio propagation? The answer is yes. Though, wind directly does not affect radio waves but it does affects the refraction (bending of the waves) capabilities of the medium which is what leads to aberration in radio propagation. Refraction is always present in the atmosphere and thus needs to be accounted for in radio propagation. When certain environmental conditions deviate from the standard conditions, a phenomenon known as ducting occurs and it leads to long radio propagation thus causing the wave to bounce off to the earth. Some researchers like Joseph Amajama and Daniel Effiong Oku (2016), also argued that wind has a marked effect on radio signal. In our research, we have seen that winds do not just affect the antenna or the receptor (radio or phone), but it has an effect on telecommunication signals. This is due to the fact that UHF of radio waves in the KU band spectrum are of shorter wavelengths and attenuations in this radio paths are mostly by absorption and scattering of dust and sand particles caused by the movement of wind.

V. Conclusion

In Satellite Transmission, There Are Always Losses From Various Sources. Some Of Those Losses May Be Constant, Others Are Dependent On Statistical Data And Others Vary With The Weather Conditions Which Include Rain, Temperature, Humidity, Pressure, Wind Speed And Direction. In This Experiment, The Results Obtained During The Analysis Between UHF Radio Signal In The Troposphere And The Atmospheric Parameters(Temperature And Wind Speed) Shows That The Variation Of This Parameters Affects Radio propagation in the study area. This finding can be used to develop efficient link margin and budget for the study area rather than using existing link margin developed from the data evaluation of other regions

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