ISSN 2347 - 3983
Volume 8. No. 4, April 2020
International Journal of Emerging Trends in Engineering Research
Available Online at http://www.warse.org/IJETER/static/pdf/file/ijeter36842020.pdf
https://doi.org/10.30534/ijeter/2020/36842020

Modes of Radio Wave Propagation: Troposcatter

Aaron Don M. Africa, Shawn Reece T. Wu, Isaiah Kyle A. Naco,
John Joseph M. Castillo, Victor Antonio R. Valdes
De La Salle University, Manila
2401 Taft Ave., Malate, Manila 1004,
Philippines, aaron.africa@dlsu.edu.ph

ABSTRACT

This paper discusses the Yagi-Uda antenna and its properties. This kind of antenna array uses several metal rods, with one rod connected to the transmission line, while the others act as a reflector and directors. The setup provides more gain and better directivity. To demonstrate the Yag-Uda's capabilities, an actual antenna array was constructed. The lengths of each element were calculated given a specific frequency. The antenna array was able to receive 9 channels with varying degrees of clarity, but the image and sounds can still be understood.

Key words: Troposcatter, point-to-point communication, Mobile Application, multiple signal classification.

1. INTRODUCTION

During the development of the modern era of technology and communications, one of the most significant problems that a person may encounter is the failure to propagate data over large distances. Accomplishing this paves the way to various changes and developments that would contribute to the betterment of society and greatly help the enhancement of our technology. Today, it may seem that the propagation of data through radio waves is simple and easy. This feat can be credited to the creation of the different propagation systems that we use today. One of the most recognized systems there is is the troposcatter system. A troposcatter system is a system that is developed in the 1950s wherein the transmission is accomplished by scattering electromagnetic waves in the troposphere; hence, the name troposcatter. This system is used in situations wherein the transmitter and the receiver are not in the line of sight with each other. In other words, the receiver would not be seen within the horizon of the transmitter [1].

In a troposcatter system, the frequencies of the signals being transmitted are in the UHF region. These signals take advantage of the troposphere which is the closest part of the atmosphere. The troposcatter antenna uses properties present in the atmosphere to propagate a signal over large distances. There are many "parts" in the troposphere that can reflect a signal. To illustrate further, this property is similar to how smoke can have the ability to reflect light. A similar phenomenon happens in the atmosphere wherein the troposphere reflects signals back to the earth's surface. A study conducted by Liu and Chen , a tropospheric scatter system can encounter three problems; namely propagation loss, refraction effects, and multipath effects. Propagation loss is simply a loss that occurs during the scattering of signals. When the scatter occurs, some signals fail to reflect properly to the chosen destination which turns into a loss. The refraction effect, on the other hand, happens when there is an inhomogeneous part of the troposcatter that causes an electromagnetic wave to curve or to slow down which causes an error. Finally, the multipath effects happen when there are numerous scatterers and interferences present in the troposphere. For the project, the troposcatter system of radio wave propagation would be discussed and analyzed thoroughly to understand more about its potential capabilities and utility [2].

2. BACKGROUND OF THE STUDY

Throughout the years, networks have altered the way people communicate and share information. Data transmitting and receiving through considerable distances is critical for communication since we live in a world wherein people who are far apart desired to have crystal clear connection. A troposcatter (tropospheric scatter) is a mode of radio wave propagation used to cover far distances. In the norm, signals that are microwave moves in a linear manner which makes it only susceptible to a line of sight application meaning that the transmitter can be seen by the receiver and vice versa specifically at a range of 30 to 40 miles. Utilizing the troposcatter as a mode of radio wave propagation gives access to a microwave frequency to cover considerable and far distances. It was said to be developed at around the 1950s and was mainly used for the military until the founding of large communication satellites which replaced it during the 1970s. The troposphere has a high proportion of moisture and is turbulent, frequencies at around 2Ghz are optimal for this system since this certain frequency adapts well with the moist, turbulent sections of the troposphere and is best at improving the SNR (Signal to Noise Ratio). With the application of Raytheon's experience at satellite communication and radio for over 40 years, the development of troposcatter products have been ongoing and continually progressing. From data transmitting speeds of 1Mpbs during the 70s to having ashattering 100Mpbs as the latest development which is by far the quickest data sending speed at the industry. Not only does it provide high-speed data transmission but also upgraded range, efficiency, feasibility, and security. It is said to be the ideal solution for military command centers, mobile posts, offshore communication links, wide distance coverage, and emergency contact communication purposes [3,4].

3. STATEMENT OF THE PROBLEM

During the advancement of the cutting-edge time of innovation and communication, one of the most pressing issues that an individual may experience is the ability to relay information over huge distances. Achieving this clears approach to different changes and advancements that would add to the improvement of the general public and significantly help the upgrade of the technology of our time. Today, data transmission through radio waves might be untaxing and simple. This accomplishment can be credited to the making of the diverse propagation systems that we use today. One of the most perceived propagation systems there is is the troposcatter system. The research aims to address long-distance data transmitting as it operates at the Ultra High-Frequency region which makes it optimal for communication to cover huge distances specifically at a 190-mile coverage. It is a mode of wave propagation wherein the transmission is accomplished by scattering electromagnetic waves in the troposphere which is the nearest layer of the atmosphere from the earth's surface.

4. SIGNIFICANCE OF THE STUDY

Nowadays, one of the most important aspects of an individual's life is communication. Communication is a vital part of society and is one of the driving forces to our advancement as a species [5]. One of the early problems regarding communication is distance. In the past, moving data from one point to another proved to be difficult and costly [6,7]. After the discovery of radio wave propagation, communication over distances, however, seemed more and more simple. One type of radio wave propagation that will be discussed and studied thoroughly in this project is the troposcatter [8]. A troposcatter is mostly used for the transmission and reception of data wherein the transmitter and receiver are out of sight of each other. Studying the troposcatter system is vital in the advancement of communications as it can help improve the efficiency and the effectiveness of the system. It has already been proven by a study conducted by Liu and Chen (2018) that a troposcatter is vulnerable to different types of error. Studying these errors would bring a new understanding of the ways and different areas wherein a troposcatter can improve. Also, studying the effectiveness of the system would open new opportunities and ideas that could develop into even more advanced systems [9,10].

5. DESCRIPTION OF THE SYSTEM

The system is a passive troposcatter location system. The system accounts for many characteristics that will help it handle beyond-line of sight communications. Characteristics like propagation loss, refraction effect, and multipath fading were put into consideration to allow the system to work.

To get the best operating range, we assume that the location system has the best azimuth. To receive multiple signals and understand them, the multiple signal classification algorithm was used. Forward and backward spatial smoothing was used to get better data.

6. METHODOLOGY

The researchers wanted to make a system that was capable of using troposcatter propagation. To do this, multiple factors had to be considered. The local topography had to be tested to see which location is best for the stations. The researchers looked for the highest possible land because troposcatter propagation is best at high altitudes. MUSIC algorithm was used to classify multiple and different signals at the same. The researchers made sure that the stations had a good line of sight between each other for troposcatter to be effective.

7. REVIEW OF RELATED LITERATURE

A research paper made by Zhang, Hackworth, and Scoff is all about troposcatter in VHF use of frequency. VHF troposcatter is the main thing that they have research. The idea was that linking two or more things, then make the troposcatter possible utilizing LOS link (line of sight link). With the scattered energy, it is made possible to have a connection in a faraway place. Having a connection a beyond the line of sight is very overwhelmingly very useful. This is what this paper is trying to do, to find what angle of scattering and etc to make connections beyond the line of sight by using VHS frequency[11].

Another research made by Prasad and Sakar is all about the suitable prediction technique for calculating the received signal levels. The idea of being able to predict the in calculating the signal reception is very useful so that with prediction many things can be done faster. Reducing the interference problems and improving the reliability of links is the solution that they are trying to predict with the algorithm that they have made. Considering this would be beneficial in a lot of ways and can help the maker/ engineer may be to make the decision making faster with the help of the predicted problems[12].

Another research made by Li, Wu, Zhuang, and Zhao, they have made an idea where prediction again, but now the difference is predicting troposcatter transmission loss, so optimizing the correlation coefficients of propagation path conditions utilizing the modern optimization algorithm they have made. They have made use of the several statistical relativities of troposcatter transmission loss as captured by changing frequency, path length, scattering angle, and meteorological condition, from that each analyzed using the terrestrial trans-horizon propagation loss data banks released by the International Telecommunication Union (ITU) was used so that it is proven to be true. So this paper has shown quite the result showing that the best results possible and was seen to be better than the one without the algorithm [13].

8. THEORETICAL CONSIDERATIONS

There are many aspects and studies concerning the workings of a troposcatter system. The system may encounter interference and obstacles which would make it harder for a receiver to accept a clear signal to decode. According to a study conducted by Dinc and Akan, it was noted that the performance of a troposcatter system is highly dependent on the moisture or "hydro-meteors" present in the sky [14]. Also noted in the paper, is the vulnerability of the system to path lengths and scattering. This is whytroposcatter systems would work better in high places where the angle of elevation of the antenna would below. Although the troposcatter system seems vulnerable to avoidable things, this system is implemented because it also comes with several benefits. A troposcatter system is widely implemented because it has benefits such as security, range, reliability and a high data rate. To implement the study on the system correctly, the researchers must take notes about the theories and the workings behind the entire system. To gather more accurate data, the problems discussed must be taken into consideration in the research of the students. Studying the troposcatter system would push the students into studying the properties of radio waves and the atmosphere [15,16,17].

9. DATA AND RESULT

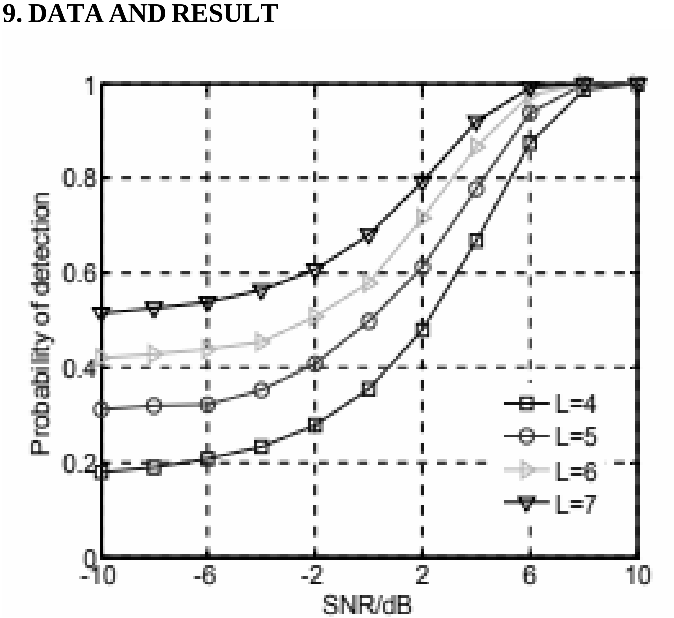

Figure 1: Data Part 1

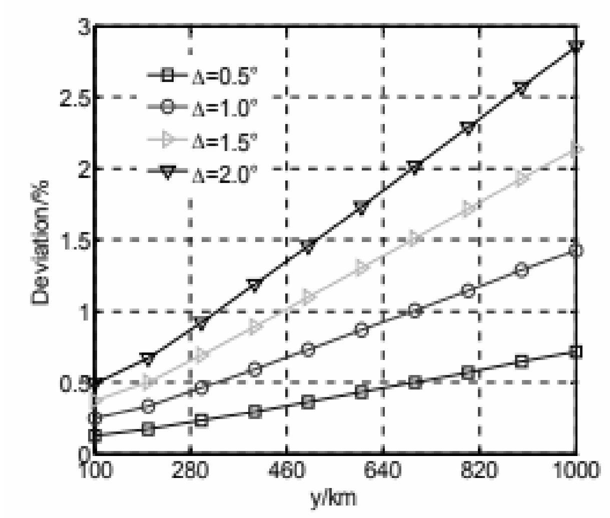

Figure 2: Data Part 2

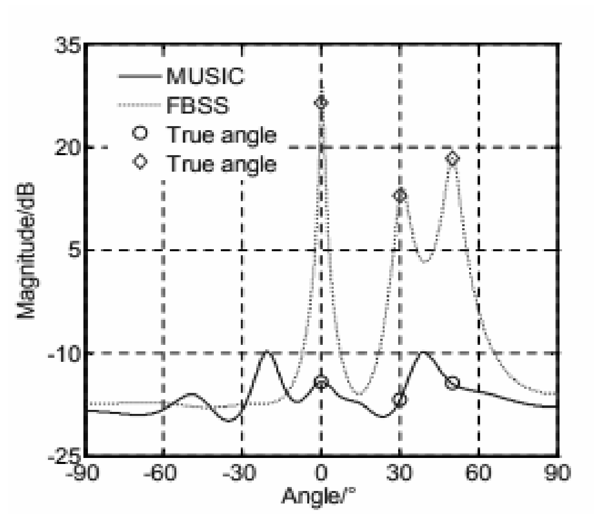

Figure 3: Data Part 3

10. ANALYSIS OF THE DATA

Figure 1 shows the probability of detection of the signal changing with SNR. This shows that the higher the SNR and the more terminal nodes there is, will better performance the more the system will perform better.

From Figure 2, the location performance is determined by the azimuth bias. Based on this, the use of an array antenna can produce a more accurate direction-of-arrival (DOA) estimation than the parabolic
antenna.

In Figure 3, after performing forward and backward spatial smoothing, the DOA can be accurately estimated by the multiple signal classification algorithm (MUSIC). The MUSIC algorithm is made invalid by the coherent signals. The performance of the spatial smoothing algorithm is still good but it decreases the array aperture. This means that the maximum number of resolved sources will be limited.

11. CONCLUSION

This paper discusses what the troposcatter mode of radio wave propagation is. It also provides data on the viability and capability of a passive troposcatter location system. Tropospheric scatter is used when frequencies at the HF to VHF/UFH bands, and even to the microwave bands. What makes troposcatter propagation an effective mode of radio wave propagation is that it is possible to get somewhat precise estimates of path loss [18,19].

Antenna height, the local topography, and station separation are important in calculations. This allows anyone handling a tropospheric scatter propagation system to accurately predict what changing each parameter will do to the signal strength of the system[20,21].

Tropospheric scattering occurs mostly in the signal's original direction. When the scattering angle increases, the magnitude of the scattering loses potency very rapidly, so this method is only effective when the scattering angle is only a few degrees big. When considering using this propagation mode, two factors should be considered in determining which scattering angle to use between two stations. The first is the distance between the stations and the second is the "take-off angle" at the two stations, which is, it's the angle between a horizontal ray from the antenna and a ray from the antenna to the radio horizon. The take-off angle heavily influences the path loss of the signal. If the take-off angles are large, then the scattering angle will also be large and the scattering volume will reach high altitudes. This shouldn't happen because the atmosphere is thinner which will diminish the scattering process.

12. RECOMMENDATION

This kind of topic can be used in a lot of ways to make to communicate. since the project topic is all about troposcatter, then we think of communication [22].

On flat ground, using a vertical stack of two horizontal beams will concentrate the energy at the lowest radiation angle determined by the average antenna height, so stacking is recommended, but stacking does not "pull-down" the radiation angle[23,24]. Stacking requires a higher tower to get the same angle of radiation. If the situation is a fixed tower height consider, that stacking will mean more power in the lowest loop, which will be at a higher radiation angle than using just one antenna at the top.

The net result of stacking two beams relatively low over the ground will be more power below 1 degree for instance, where it counts for troposcatter, but not an improvement of the expected. The net result is dependent on the tower height and the terrain (flat or sloping), so do some calculations for the situation. If in the case recommended and wanted is to improve for troposcatter and the tower is only a few wavelengths high, it is best to put off up just one beam with the double boom length at the top of your tower [25,26].

There is another paper where the idea was troposcatter link in the ccir recommends that the antennas should be pointed slightly above the horizon. The purpose of this beam tilt seems to be to have less noise pickup from the ground at 270 ° K and less man-made noise. This is assumed to be only valid at SHF and for shorter distances[27,28,29,30]. If ever the system will be implemented in a computer software, it can follow the sample algorithms in [31,32].

REFERENCES

[1] P. Varunkumar, and K. Aparna, "Performance of Troposcatter Communications with Different Diversity Technique on Fading Correlation Analysis. Performance OfTroposcatter Communications with Different Diversity Technique on Fading Correlation Analysis", Vol. 5, No. 7, 2017.

[2] Z. Liu, X. Chen, and Q. Liu,"Research on Passive Troposcatter Location System. Radio engineering", Vol. 27, No. 1, 2019. https://doi.org/10.13164/re.2019.0312

[3] A. Africa, I. Naco, J. Castillo, V. Valdes, and S. Wu, "Ann distance protection for transmission lines," International Journal of Emerging Trends in Engineering Research. Vol. 7, No. 8, pp. 145-150, 2019. https://doi.org/10.30534/ijeter/2019/07782019

[4] A. Africa, A. Mesina, J. Izon and B. Quitevis "Development of a novel android controlled USB file transfer hub," Journal of Telecommunication, Electronic and Computer Engineering. Vol. 9, No. 2-8, pp. 1-5, 2017..

[5] N. Wang, "The troposcatter loss estimation by the uniform path-loss model based on power balance theory," 2017 7th IEEE International Symposium on Microwave, Antenna, Propagation, and EMC Technologies (MAPE). 2017.

[6] C. Li, X. Chen, and X. Liu,"Cognitive Tropospheric Scatter Communication,"IEEE Transactions on Vehicular Technology, Vol.67, No.2, pp.1482-1491, 2018.

[7] W. Zhang, J. Hackworth, and W. Schoff,"A Study of VHF Troposcatter Communication Channels in South Australia, "Retrieved from https://link.springer.com/chapter/10.1007/978-1-4615-6119-4_12, 1997.

[8] M. Prasad andS. Sarkar,"Evaluation of the suitability of troposcatter prediction techniques over Northern," Retrieved from https://link.springer.com/article/10.1007/BF02999745.

[9] A. Africa, G. Ching, K. Go, R. Evidente, and J. Uy, "A comprehensive study on application development software systems." International Journal of Emerging Trends in Engineering Research. Vol. 7, No. 8, pp 99-103, 2019.

[10] L. Torrizo, and A. Africa. "Next-hour electrical load forecasting using an artificial neural network:

Applicability in the Philippines," International Journal of Advanced Trends in Computer Science and Engineering. Vol. 8, No. 3, pp 831-835, 2019.
https://doi.org/10.30534/ijatcse/2019/77832019

[11] L. Yeh,"Simple Methods for Designing Troposcatter Circuits," IEEE Transactions on Communications. Vol. 8, No. 3, pp. 193-198, 1960.

[12] W. Gordon, "A simple picture of tropospheric radio scattering," IRE Transactions on Communications Systems. Vol. 4, No. 1, pp. 97-101, 1996.
https://doi.org/10.1109/TCOM.1956.1097260

[13] K. Norton, and J. Wiesner, "The Scatter Propagation Issue," Proceedings of the IRE. Vol. 43, No. 10, pp. 1174-1174, 1995.

[14] R. Merrill,"Optimum antenna height for ionospheric scatter propagation," IRE International Convention Record.

[15] R. Merrill, and W. Mansfield, "Radiation patterns in the lower ionosphere and Fresnal zones for elevated antennas over a spherical earth," 1962.
https://doi.org/10.6028/NBS.MONO.38

[16] J. Grosskopf, "Wellenausbreitung,"Mannheim: BibliographischesInstitut. 1997.

[17] W. Burrows,"V.H.F. radio wave propagation in the troposphere,"London. 1998.

[18] J. Voge, and P. David, "Propagation of waves,"Oxf. 1969.

[19] G. Roda,"Troposcatter radio links,"Norwood: Artech. 1988.

[20] A. Africa, A. Alcantara, M. Lagula, A. Latina and C. Te, "Mobile phone graphical user interface (GUI) for appliance remote control: An SMS-based electronic appliance monitoring and control system," International Journal of Advanced Trends in Computer Science and Engineering. Vol. 8, No. 3, pp. 487-494, 2019..

[21] O. Rydbeck,"Dynamic Non-Linear Wave Propagation In Ionized Media. 7. Non-Linear Plasma Waves In A Streaming Homogeneous", Cold Ionized Medium. 1996.

[22] D. Evans, and R. Britain, "VHF/UHF manual,"London: Radio Society of Great Britain. 1996.

[23] "The ARRL UHF, microwave experimenters handbook: Antennas, components and design"., Newington, CT: American Radio Relay League. 1991.

[24] A. Bazzi, "Radio communications,"Vukovar, Croatia: In-Teh. 2010.
https://doi.org/10.5772/228

[25] H. Herrick,"Radio communications in the digital age. Rochester," NY: Harris. 2000.

[26] "Tropospheric scatter". Retrieved from https://www.its.bldrdoc.gov/fs-1037/dir-038/_5617.htm.

[27] Global, I., AFNET to herald network centric operations in IAF - IFSEC Global: Security and Fire News and Resources. Retrieved from
https://www.ifsecglobal.com/uncategorized/afnet-to-herald-network-centric-operations-in-iaf/. 2016.

[28] Kopp and Carlo, "Tropospheric Scatter Communications Systems". Retrieved from
http://www.ausairpower.net/APA-Troposcatter-Systems.html. 2010.

[29] "Guyana-1968-0.40," Retrieved from
http://www.ipernity.com/doc/777361/48870628.

[30] Burt, "Telecommunication in Barbados 1930's to 1980". Retrieved from
https://www.bajanthings.com/cable-and-wireless-in-barbados/. 2019.

[31] A. Africa, F. Espiritu, C. Lontoc, and R. Mendez, "The integration of computer systems into the expansive field of video games," International Journal of Advanced Trends in Computer Science and Engineering. Vol. 8, No. 4, pp. 1139-1145, 2019.
https://doi.org/10.30534/ijatcse/2019/22842019

[32] A. Africa, P. Arevalo, A. Publico, and M. Tan, "A comprehensive study of the functions and operations of control systems," International Journal of Advanced Trends in Computer Science and Engineering. Vol. 8, No. 3, pp. 922-926, 2019.
https://doi.org/10.30534/ijatcse/2019/89832019