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Signal Strength Analysis of an FM Radio Station's Test Transmission

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ABSTRACT

The aim of this research work was to assess the signal strength variation of an FM radio station on 99.3 MHz frequency during a test transmission in Abuja, Nigeria. The signal strength was measured in a location in Abuja Municipal Area Council (AMAC) from Monday to Friday, 7:0 AM – 7:00 PM. The one-week data was averaged, and the analysis performed using graphical and tabular representations. The result indicates a highly stable transmission throughout the observation period. The recorded values ranged between 47.34 dBμV and 47.73 dBμV, showing a minimal variation of less than 0.40 dBμV. This consistency demonstrates strong broadcast reliability with negligible fading or interference. The result also shows that the signal exhibited a slight midday decline, likely due to increased urban electromagnetic activity and atmospheric heating, followed by stabilization and a gradual evening rise as conditions became more favourable. From the results, it was concluded that the transmission system performed efficiently and maintained stable signal levels throughout the study period of five days. It was recommended that similar test be carried out in other parts of Abuja to determine the signal reception quality and behaviours in those areas. This result will be valuable to the radio station, and other researchers in the radio communication fields.

KEYWORDS: *Atmospheric condition, Antenna, Signal strength, Signal attenuation, Test transmission.*

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1. INTRODUCTION

Radio signal strength is defined as the power or intensity of a radio signal as it is received by a radio antenna or receiver, and which is determined by some factors such as Distance from the transmitter; Terrain such as Hills, mountains; Atmospheric Conditions such as Weather, ionospheric changes, and tropospheric conditions; Transmitter Power; Antenna Quality such as the type, and orientation of the antenna as well as Interference. As stated by Sheu (2021), the transmission of radio signal is affected by primary meteorological variables like atmospheric pressure, temperature and water vapor and secondary weather conditions in the troposphere.

The condition of the atmosphere can cause loss of signal (Amajama, 2016), and this will lead to poor quality of signal received at particular destinations. In addition, weather components as well as building and vegetation, affect radio wave propagation and this can create various impacts including making radio signals to be heard far away beyond its ordinary range or resulting in signal interference (Ojo et at al., 2008, Alade 2013, Ayegba, 2022). Due to the absorption and scattering of radio signal by atmospheric or space particles, the quality of the radio frequency signal diminishes as it travels through the atmosphere and across the link, and this reduction in signal strength has a significant effect on the information received at any point (Ale et al., 2024). Attenuation is the reduction in radio signal strength transmitted or received and, may be caused by signal transmission over a long distance. The decrease in the level of signal in the troposphere or atmosphere in general as a result of noise from electrical networks and

influenced by some atmospheric elements is a major concern when one propagates radio signal through the atmosphere (Yabwa et al, 2023). Though some related works have been done, none has been done on this new radio station which is currently doing its test transmission, hence, the need for this work.

2. A brief about Abuja, the study area

Abuja, the capital city of Nigeria, is centrally located within latitude 8.25° and 9.20° North of the equator and longitude 6.45° and 7.39° East of the Greenwich meridian. It was established as the capital in 1991 to replace Lagos. The region lies within the Guinea Savannah vegetation zone, marked by a blend of woodland and with tall grasses, scattered shrubs, and trees. The rainy season of Abuja is between April and September, while the dry season is between October and March. Abuja has a temperature range of around 26°C to 40°C and around 20°C to 30°C in the rainy season, and the area receives an average of 1,200 mm of rainfall**.** The city is characterized by undulating terrain, with prominent features such as Aso Rock and Zuma Rock that define its landscape and topographical features.

3. Materials and method

The materials used in this work are stop watch, digital signal strength meter, Yagi-Uda antenna with a coaxial cable, the frequency of the radio station (99.3 MHz). The research work made use of primary data which was measured by the researchers over a duration of one week beginning from Monday, October 27 to Friday, October 31, 2023. The objective was to assess the signal behaviour over a 12-hour period to determine transmission reliability and quality within the region.

3.1. Data Collection

The signal strength was measured using a calibrated FM signal strength meter capable of detecting field strength in decibel microvolts (dBμV). The device was positioned at a fixed monitoring point within the broadcast coverage area to eliminate the influence of movement or terrain variation. Measurements were taken at 30-minute intervals from 7:00 AM to 7:00 PM, Monday through Friday, to capture regular variations in signal strength due to environmental and atmospheric conditions. The data recorded encompassed 25 half-hourly readings per day, and the values used in this study represent the average signal strength for each time interval across the week, thus reducing anomalies or outliers.

3.2. Data Presentation and Analysis

The recorded signal strength values were tabulated in a spreadsheet and subsequently plotted using a line graph to visually represent the signal variation across the monitored time period. The graph and table were analyzed to identify patterns, trends, or anomalies in the signal behaviour. Statistical observations focused on detecting fluctuations, determining peak and low periods, and assessing the overall stability of the broadcast signal.

4. Results and Discussions

4.1. Analysis of FM Radio Signal Strength Data

Table 1.0 shows the average FM radio signal strength measured at half-hour intervals from 7:00 AM to 7:00 PM at a selected test location in Abuja Municipal Area Council (AMAC), Abuja during the station's preliminary transmission (Test-transmission) phase of a new radio station currently in Abuja, Nigeria. The measured values ranged from 47.34 dBμV to 47.73 dBμV, which indicate a generally stable signal throughout the 12-hour observation period, with a total variation of only 0.39 dBμV, a narrow fluctuation margin which reflects minimal interference or propagation loss at the receiving point.

The signal strength is highest during the early morning hours, beginning at 47.72 dBμV at **7:**00 AM, and remains above 47.6 dBμV during the first two hours. This stability in the morning is typically associated with low atmospheric disturbance and reduced electromagnetic noise due to lower human and industrial activity. But between 9:30 AM and 12:00 PM, a slight decline is observed where the signal reduces to its minimum value of 47.34 dBμV at 12:00 PM. This reduction in the midday could be as a result of increased temperature and higher levels of urban RF interference, both of which can affect VHF/FM propagation. From 12:30 PM to 4:00 PM, the signal stabilizes within a narrow range (47.40–47.53 dBμV), which indicates that the transmission path and receiving conditions remained relatively constant during this period. There was no abrupt fading or spikes recorded, and this implies that there was an absence of significant multipath distortion or obstruction at the test site. Towards the evening, a progressive increase in signal strength is recorded from 5:00 PM onward, with the peak signal strength being 47.73 dBμV at 7:00 PM, which is the highest value of the dataset. This result is conformity with the results of the works by *Ayegba et al.,* (2022). The evening improvement is consistent with typical FM propagation behaviour as atmospheric cooling reduces refractive turbulence and urban RF noise declines or reduces.

Table 1: Average hourly signal strength of the FM Radio station

Time	FM Radio Average signal strength (dBμV)
7.00 am	47.72
7.30 am	47.7
8.00 am	47.55
8.30 am	47.7
9.00 am	47.61
9.30 am	47.68
10.00 am	47.48
10.30 am	47.41
11.00 am	47.54
11.30 am	47.43
12.00 pm	47.34
12.30 pm	47.39
1.00 pm	47.49
1.30 pm	47.51
2.00 pm	47.49
2.30 pm	47.49
3.00 pm	47.4
3.30 pm	47.49
4.00 pm	47.41
4.30 pm	47.53
5.00 pm	47.46
5.30 pm	47.45
6.00 pm	47.59
6.30 pm	47.65
7.00 pm	47.73

4.2. Interpretation of the graph of FM Radio Signal Strength Variation

Fig. 2.0 represents the variation in FM radio signal strength measured at half-hour intervals between 7:00 AM and 7:00 PM in Abuja during a controlled test transmission. The graph shows that the signal strength is relatively high during the early morning hours, with values remaining above 47.6 dBμV between 7:00 AM and 9:00 AM. This stability is characteristic of favourable early-morning atmospheric conditions and lower levels of urban electromagnetic activity. However, a slight but consistent reduction occurs between 10:00 AM and 12:00 PM, where the signal strength reaches its lowest point of 47.34 dBμV. This midday decrease corresponds with increased temperature and heightened human activity, both of which contribute to variations in radio wave propagation. But, the signal stabilizes again within a narrow band between 12:30 PM and 4:00 PM**,** which suggests reduced impact from environmental changes and a steady transmission path. The graph reveals a gradual upward trend from **5:**00 PM onward, with the highest strength recorded at **7:**00 PM. The evening improvement in the signal strength of the radio station is typical of FM propagation, as reduced atmospheric heating and lower interference levels provide more favourable reception conditions. From the table and the graph, the measured data demonstrates that the FM transmission is highly stable in terms of signal quality reception. The small difference between maximum and minimum recorded values confirms that the transmitter and antenna configuration are functioning efficiently, with no evidence of severe fading, shadowing, or abnormal interference.

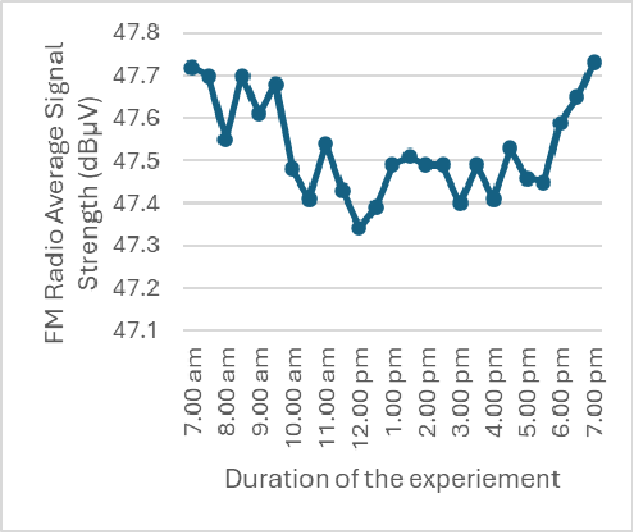

Fig. 1.0: Graphical representation of Average hourly signal strength of the FM Radio station

5. Conclusion

The analysis of the FM radio (99.3 MHz) signal strength data, obtained from half-hour measurements between 7:00 AM and 7:00 PM in Abuja, demonstrates a highly stable and reliable transmission performance during the test broadcast. The analysis of the FM radio signal strength measured from 7:00 AM to 7:00 PM in Abuja indicates a highly stable transmission throughout the observation period. The recorded values ranged between 47.34 dBμV and 47.73 dBμV, showing a minimal variation of less than 0.40 dBμV**.** This consistency demonstrates strong broadcast reliability with negligible fading or interference. The signal exhibited a slight midday decline, likely due to increased urban electromagnetic activity and atmospheric heating, followed by stabilization and a gradual evening rise as conditions became more favourable. In conclusion, both the table and the plotted graph confirm that the transmission system performed efficiently and maintained stable signal levels throughout the study period of five days. This result will be valuable to the radio station, and other researchers in the radio communication fields.

6. Recommendation

It is recommended that similar test be carried out in other parts of Abuja to determine the signal reception quality and behaviours in those areas.

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