Estimation of Specific Attenuation of Radio Signal in Southwest Nigeria

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Abstract – Radio signals could be attenuated by different atmospheric parameters. The magnitude at which the radio signals attenuate depends greatly on the signal power, frequency and state at which the troposphere through which the signals propagate. In this study, specific attenuation of radio signal in southwest Nigeria is determined using some weather parameters. The results were compared with the one given by International Telecommunication Union Radiowave Propagation (ITU–RP). The experimental specific attenuation of southwest Nigeria is 0.0585 dBkm⁻¹ while that of ITU–RP is given as 0.05 dBkm⁻¹. If this value is rounded up to two decimal places it results to 0.06 dBkm⁻¹. It is therefore recommended that transmitters to be used for radio propagation in southwest Nigeria should be designed in such a way that this experimented value would have been taken into consideration for maximum output.

I. INTRODUCTION

Attenuation can be defined as the reduction in the strength at which a signal propagates. This could occur either as analog or digital transmission. Radio wave signals’ transmission in the tropospheric zone of the earth is greatly disturbed by variations in some weather parameters such as temperature, humidity and pressure [1, 2]. These variations are caused as a result of change in weather over seasons of the year. The quality of the signals received from radio wave and probability of its attenuation is majorly controlled by radio refractivity index gradient which is as a result of variations in weather parameters (temperature, pressure and humidity) [3]. Generally, radio wave propagation speed in a vacuum is equal to the speed of light. In material medium, radio waves’ speed is approximately estimated as the ratio of the speed of light in a vacuum to the ratio of the speed of light in a vacuum. The radio refractive index value for dry air (peculiar to lower troposphere) is approximately equal for light waves and radio waves, but the radio refractive index value for water vapour differs for the light waves and radio waves. The reason for this variation is that water vapour molecule has a permanent dipole moment which has different responses to the electric forces of frequencies of different radio waves transmitted within the atmosphere.

In Nigeria, attenuation of radio signals had been the major challenge in telecommunication companies which is yet to be resolved till date. The reason is that there are difficulties in overcoming the standard loss of the signal as estimated by ITU–RP [4] for installed transmitters in Nigeria as 0.05 dBkm⁻¹. In this study, the specific attenuation of a radio signal would be re-estimated using Nigerian meteorological data in order to determine the correlation between ITU value and estimated value. However, Akinwumi et al. [5] investigated on the atmospheric gases attenuation in West Africa and concluded that gaseous attenuation has little effects at lower frequencies than other impairments like rain. This conclusion has initiated this study in order to ascertain the impact of relative humidity and temperature on signal propagation in southwestern region of Nigeria.

Mandelstan [6] reported that gradual loss in the intensity of a flux through any medium is known as attenuation. Attenuation seriously affects the waves and signals’ propagation in radio waves. Before a specific attenuation could be estimated, it is imperative to note that the attenuation coefficient of the cloud and the liquid water density are determined. The attenuation coefficient is the quality that characterizes how a material could be penetrated easily by sound particles, beam of light, or other energy sources. It is the inverse of the depth of penetration and its unit is measured as the inverse of length. It describes the extent to which the intensity of energy beam is greatly reduced when it passes through a material medium [7]. The liquid water density is the measure of the mass of water in a cloud in a specified amount of dry air.

II. MATERIALS AND METHODS

Weather parameters for the six states in southwest region of Nigeria were obtained from Nigerian Meteorological Agency (NIMET). The analyses were done for a period of twelve months in the year 2012.

The specific attenuation ($Y_c$) of the cloud in dBkm⁻¹ is estimated using (1).

$$Y_c = K_c \times M$$ (1)
Where $K_c$ is the specific attenuation coefficient of the cloud in $(\text{dBkm}^{-1})/\text{(gm}^{-3})$ and $M$ is the liquid water density of the cloud in $\text{gm}^{-3}$.

$$M = \frac{RH}{100} \tag{2}$$

Where $RH$ is the relative humidity

$$K_c = \frac{0.819 f}{\varepsilon(1 + \eta^2)} \text{ (dBkm}^{-1})/\text{(gm}^{-3}) \tag{3}$$

Where $f$ is the frequency in GHz and $\eta$ is the backscatter cross-section per unit volume and has relationship with temperature.

III. RESULTS AND DISCUSSION

The variation in the specific attenuation in the southwest Nigeria for Lagos, Abeokuta, Ibadan, Ondo, Ado-Ekiti and Osogbo for the year 2012 is presented in Fig. 1. The specific attenuation has high proportionality with temperature change. The more the temperature increases, the lower the level of attenuation.

![Fig. 1: Variations in specific attenuation of southwest Nigeria.](image)

The standard attenuation loss in dBkm$^{-1}$ as modeled by ITU is 0.05 dBkm$^{-1}$. However, for southwest Nigeria, the mean estimated value for the six locations used for this study is 0.0585 dBkm$^{-1}$. If this mean value is rounded up to two decimal places as given by ITU, the specific attenuation for southwest Nigeria is however 0.06 dBkm$^{-1}$. The result showed that the value is a bit greater than the recommended value. This is because the air-temperature with which the standard value was modeled differs from that of Nigeria. The estimated specific attenuation for each location is presented in Table 1.

<table>
<thead>
<tr>
<th>Locations</th>
<th>Attenuation (dBkm$^{-1}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ado-Ekiti</td>
<td>0.0558</td>
</tr>
<tr>
<td>Ikeja</td>
<td>0.0614</td>
</tr>
<tr>
<td>Abeokuta</td>
<td>0.0576</td>
</tr>
<tr>
<td>Ibadan</td>
<td>0.0562</td>
</tr>
<tr>
<td>Ondo</td>
<td>0.0608</td>
</tr>
<tr>
<td>Osogbo</td>
<td>0.0589</td>
</tr>
<tr>
<td>Mean</td>
<td>0.0585</td>
</tr>
</tbody>
</table>

IV. CONCLUSION

For propagation of radio signals to be more effective especially in southwest Nigeria, transmitters should be designed using the observed mean experimented value of 0.056 dBkm$^{-1}$. It is also deduced from the study that attenuation depends magnanimously on temperature. Further research to confirm these variations across Nigeria is recommended.

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REFERENCES


