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The Effect of Tropospheric Scintillation on Microwave Frequencies for GSM System in The Iraqi Atmosphere

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ABSTRACT- Several papers have been published recently on the effects of scintillation on microwave propagation in standard atmospheres. Most of them have analyzed theoretically the influence of various parameters on the propagation, but barely a few researchers were able to extract the results from the model relying on microwave links in a nonstandard atmosphere. A method is proposed to predict the tropospheric scintillation on the space path of Earth for both standard and nonstandard atmospheres using the frequency range (20-38) GHz which is used in the Global System for Mobile (GSM). This method can be applied to the different atmospheric conditions in different regions. This work studied the effects of various parameters, such as antenna diameter, meteorological elements *t* (average temperature), H (relative humidity), and water vapor pressure and frequency, on the scintillation magnitude of GSM bands in Basrah and Baghdad.

General Terms: Wave Propagation, Tropospheric Scintillation.
Keywords: Amplitude scintillation, fading, propagation, GSM signal.

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1. INTRODUCTION

The scintillating troposphere is proposed as the main challenge in designing a link budget of communication systems reliant on millimeter-wave and microwave in respect of the fast oscillation in the phase and amplitude of the signal [1]. The effect of scintillation occurrence can result in a major loss of SNR (Signal to Noise Ratio), which affects some parameters such as the channel frequency and the elevation angle and diameter of the antenna [2]. It can also be considered a noise source that can be predicted and utilized for optimal channel utilization [3]. Scintillation is usually defined as the fluctuations that occur about the mean level of signal power that can be received by a system which continually arises to varying degrees. It is distinct from gross fades based on the rainfall of its spectra and from deep fades based on low-angle fading of the symmetry of its Probability Density Function (PDF) [4]. Tropospheric scintillation is a rapid oscillation of the signal characteristics, which are the phase and the amplitude, caused by irregular turbulence in humidity, pressure, and temperature, which is ultimately transformed into small-scale variations in refractive index that alters with altitude [5]. Tropospheric scintillation is being studied in Libyan locations. Then, research has been accomplished concentrating on the relation between scintillation and elevation angle regarding local temperature and humidity for Libyan areas. Second, the research focuses on a scintillation prediction model that has been explored and compared [6]. In the Indian climate, researchers developed an improved new prediction methodology for tropospheric scintillations using ka band satellite signals, which is employed in adaptive link control in designing satellite communication systems [7]. The effect of tropospheric scintillation on stationary satellite communication links on the earth-space path at a frequency range between 10 and 50 GHz is being investigated for 37 stations in Nigeria [8]. For the ITU-R model, Karasawa, Otung, and Van de Kamp evaluated four clear-sky scintillation models [9]. Electromagnetic wave signals attenuated by rain, cloud, gas, and tropospheric scintillation have been the subject of several investigations throughout the years. The influence of tropospheric scintillation on the earth-space path in southwest Nigeria is been discussed [10]. Since the increased demand for bandwidth at frequencies over 10 GHz, scintillation has recently been the concern of the research. However, there has been little effort recorded regarding this area in West African countries. For the examination of tropospheric scintillation for seventeen West African sites, data from the ITU-RP research group 3 data bank was utilized as input data. The average of temperature, pressure and relative humidity were employed as input parameters on a monthly and annual basis [11].

This study investigates tropospheric scintillation caused by microwave propagation in standard and non-standard atmospheres in IRAQ, which is employed in the RF portion of the Global System for Mobile Communications (GSM).

2. PROPOSED PREIDICTION METHOD

The model of this work is based on Ahmed A.'s work [2] as well as KDD's original work in Japan [5], [12], as amended [11]. Similar to the attenuation prediction approach in CCIR Vol. V,

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a step-by-step method based on References [10] and [11] has been laid down. The modeling concept is as follows:

$$\eta_f = \left(\frac{f}{11.5}\right)^{0.45} \quad (1)$$

$$\eta_\Theta = \left(\frac{2\sin(6.5)}{\sqrt{sin^2\Theta + \frac{2h}{R_e} + sin\Theta}}\right)^{1.3} \quad (2)$$

$$\eta_{Da} = \sqrt{\frac{G(Da)}{G(7.6)}} \quad (3)$$

$$\sigma_{REF} = 0.15 + 5.2\times 10^{-3} N_{wet}\ (dB) \quad (4)$$

$$N_{wet} = \frac{3730U_{es}}{(t+273)^2} \quad (5)$$

$$e_s = 6.11\exp\left(\frac{19.7t}{t+273}\right)\ (mb) \quad (6)$$

$$\mathrm{G(R)} = 1.0 - 1.4\left(\frac{R}{\sqrt{\lambda L}}\right) \text{ for } 0 \le \left(\frac{R}{\sqrt{\lambda L}}\right) \le 0.5 \quad (7)$$
$$= 0.5 - 0.4\left(\frac{R}{\sqrt{\lambda L}}\right) \text{ for } 0.5 \le \left(\frac{R}{\sqrt{\lambda L}}\right) \le 1.0$$
$$= 0.1 \quad for\ 1.0 \le \left(\frac{R}{\sqrt{\lambda L}}\right)$$

$$L = \frac{2h}{\sqrt{sin^2\theta + sin\theta + \frac{2h}{R_e}}} \quad (8)$$

$$\sigma_X = \sigma_{REF}\cdot\eta_f\cdot\eta_\Theta\cdot\eta_{Da}\ (dB) \quad (9)$$

Where:

- R_e : The effective earth radius (=8500 km).
- h : The effective height of water vapor in the atmosphere (=2km).
- Da : The diameter of the reflector (m).
- G : The antenna diameter dependent factor.
- R : the effective radius of the circular antenna aperture (m) given by R = 0.75(D_a /2).
- N_{wet} : The wet term.
- t : The temperature in Celsius.
- U : The relative humidity (%).
- e_s : The saturated vapor pressure.
- λ : The operating wavelength (m).
- σ_x : The magnitude of scintillation (rms fluctuation) in (dB).
- L : The slant distance to the height of a horizontal thin turbulent layer.

The model incorporates the meteorological elements t (average temperature) and U (relative humidity). The model can be used in places all over the world with various meteorological conditions and standard and non-standard atmospheres. Temperature (t) and humidity (U) are obtained using an averaging method over a month to ensure that the model does not anticipate the magnitude of short-term scintillation that varies with daily weather variations. We use the metrological data of Iraq from [2] in our research of this model.

3. ESTIMATION OF THE MAGNITUDE OF SCINTILLATION IN THE STANDARD TROPOSPHERE

Several calculation results utilizing the proposed model are shown in this part. The suggested model may provide a range of estimates for scintillation fading based on metrological data, as shown in the following sections.

3.1 Frequency Effect on RMS Fluctuations

Figure 1 depicts the relationship between rms fluctuation and temperature with a frequency range (20-38) GHz when (U =60% and antenna diameter =0.4 meters).

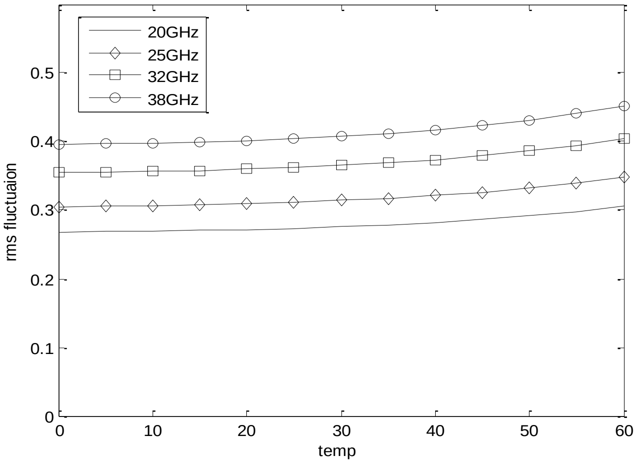

Figure 1: Frequency effect on rms fluctuation

3.2 Humidity Effect on RMS Fluctuations

At the parameters (f=38 GHz and antenna diameter =1.8 meter), the calculated rms fluctuation due to scintillation functions of temperature and relative humidity is shown in *figure 2*.

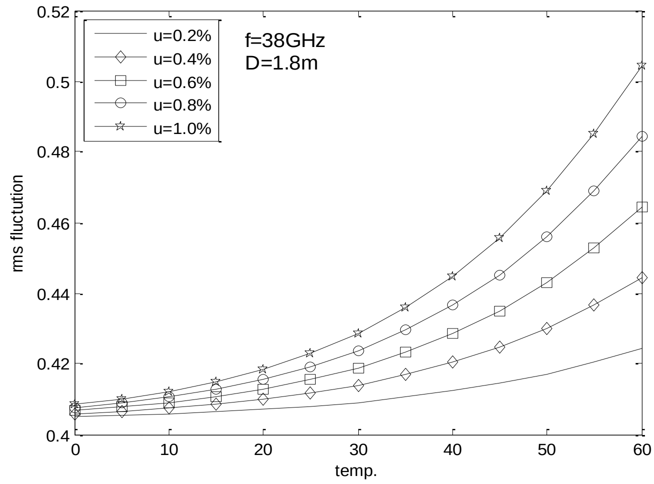

Figure 2: Humidity effect on rms fluctuation

3.3 Antenna Diameters Effect on RMS Fluctuations

Figure 3 depicts the relationship between rms fluctuation and temperature with a diameter range (0.3- 1.8 m) at the parameters (f=29 GHz and U =80%).

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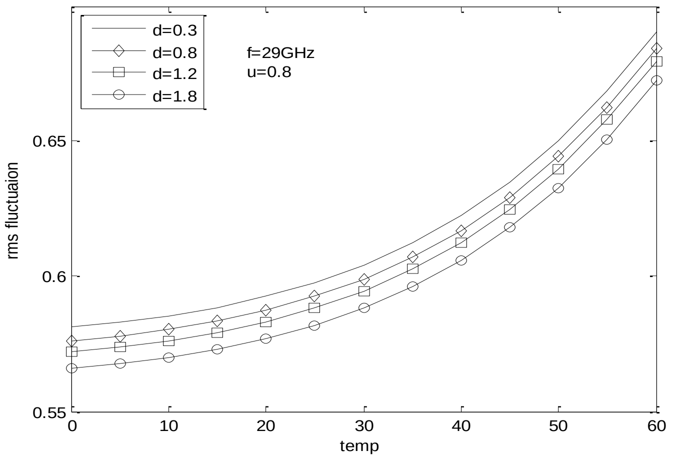

Figure 3: Antenna diameters effect on rms fluctuation

3.4 Special Case

The relationship between rms fluctuation and frequencies is shown in *figure 4*. In our research, we observed that the magnitude of scintillation is proportional to frequency, which means the magnitude increases with increasing frequency in a general form. However, the magnitude of scintillation is greater in the range of frequencies (24 – 29) GHz. When the frequency is roughly 26 GHz, the peak in the magnitude of scintillation occurs.

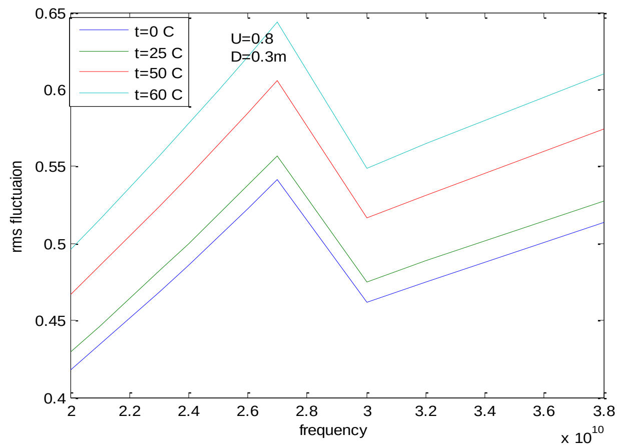

Figure 4: RMS fluctuation with frequency at different temperatures

4. ESTIMATION OF THE MAGNITUDE OF SCINTILLATION IN THE NON-STANDARD TROPOSPHERE

The estimated magnitude of scintillation in standard troposphere results has been shown. This section shows the estimated magnitude of scintillation in non-standard troposphere results as in the following sections.

4.1 Frequency Effect on RMS Fluctuation

Figure 5 depicts the relationship between rms fluctuation and temperature with a frequency range (20-38) GHz when (humidity equal to 80% and antenna diameter =0.3 meters).

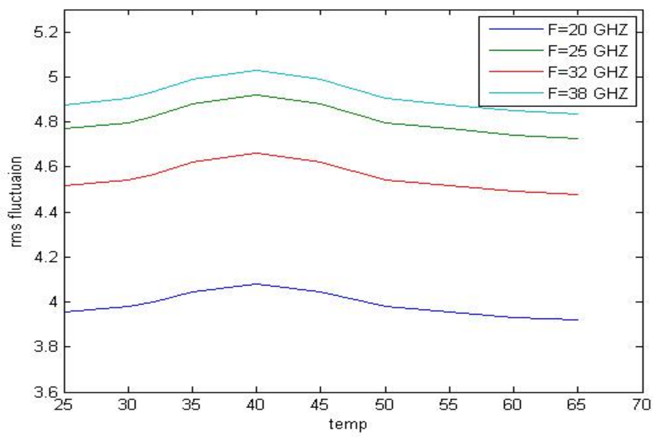

Figure 5: Relationship between temperature and rms fluctuation with different frequencies

4.2 Antenna Diameters Effect on RMS Fluctuations

At the parameters (f=38 GHz and U =80%), the relationship between rms fluctuation and temperature with diameter range (0.3- 1.8m) is shown in *figure 6*.

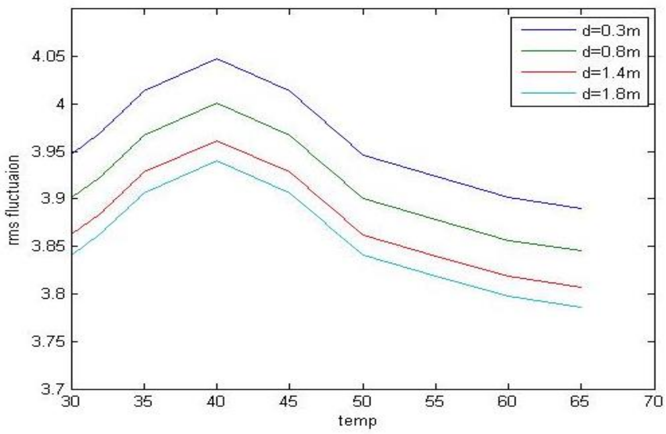

Figure 6: Rms fluctuation with temperature at different Antenna diameters

4.3 Humidity Effect on RMS Fluctuation

At the parameters (f=35 GHz and antenna diameter =1.4 meter), *figure 7* illustrates the calculated rms fluctuation due to scintillation functions of temperature and relative humidity.

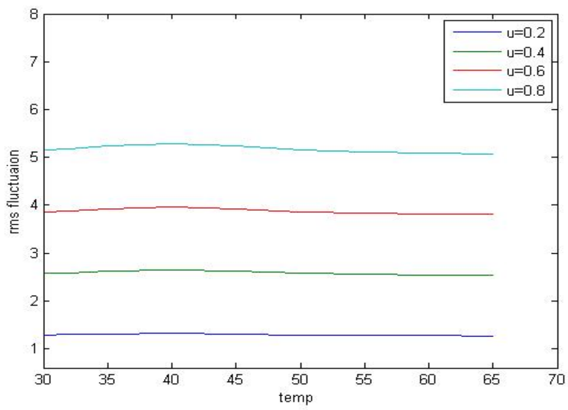

Figure 7: Humidity effect on rms fluctuation with in non-standard troposphere

5. CONCLUSION

A technique was presented for predicting scintillation fading on earth's space path at a range of frequencies utilized in the RF section of the Global System for Mobile (GSM) for both standard and non-standard atmospheres. The recommended strategy was used in the cities of Baghdad and Basrah. The following are summaries of the most important conclusions.

As the frequency rises, the amplitude of scintillation rises as well. In both normal and non-standard atmospheres, the maximum magnitude occurs at 25 GHz.

Furthermore, when the humidity rises, the magnitude of scintillation rises as well. In a non-standard atmosphere, the peak rms fluctuation occurs at about 40C°.

Additionally, as the antenna diameter grows, the magnitude of scintillation drops, and the peak rms fluctuation occurs around 40Co in a non-standard Atmosphere.

Finally, in both normal and non-standard situations, the magnitude of scintillation rises as the temperature rises. The magnitude of scintillation reaches its highest around 40C° in non–standard conditions.

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