5G Millimeter Wave (mmWave) Communication System with Software Defined Radio (SDR)

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ABSTRACT

5G Millimeter Wave (mmWave) Communication System will provide high speed data connection with minimal latency to full-fill the upcoming user demand and need by 2020. 5G Millimeter Wave (mmWave) Communication System can provide multigigabit data rates for the several users at a time. This paper presents atmospheric attenuation control in 5G millimeter wave (mmwave) communication system for Delhi (India) based location using software defined radio (SDR). The software defined radio atmospheric attenuation is calculated for the frequencies 28 GHz, 37 GHz and 39 GHz. The atmospheric attenuation is calculated for Delhi (India) based location by considering 5G millimeter wave (mmWave) absorption due to atmospheric water vapour and atmospheric oxygen.

Keywords - Millimeter Wave (mmWave); software defined radio (SDR); Radio Frequency (RF)

I. INTRODUCTION

By 2020 demand and need for the mobile broadband will be very high and existing system will not be able to fulfill the user demand globally. 5G Millimeter Wave (mmWave) Communication System will be capable to provide low latency , high speed internet connection to the users across the Globe in an efficient manner. 5G Millimeter Wave (mmWave) Communication System can provide multi-gigabit data rates for the users across the Globe. Continuous increasing mobile internet data demand making 3 GHz spectrum overloaded. Further, there is another set of frequencies under millimeter wave (mmwave) frequency band which is under consideration for 5G millimeter wave (mmwave) communication system. The millimeter wave (mmwave) frequency spectrum is ranging from 3 GHz to 300 GHz. Research and development is in progress to identify the suitable frequency bands in millimeter wave (mmwave) frequency spectrum [1-4].

5G Millimeter Wave (mmWave) Communication System can attain multigigabit data rates for mobile broadband users. In this paper, we are discussing the mmWave 3–300 GHz spectrum along with the effect of atmospheric attenuation and its controlling along with compensation at the transmitter side. There is a requirement to provide the transmission power control in an efficient manner so that system can recognize the requirement of the transmission power. SDR based 5G Millimeter Wave (mmWave) Communication System can provide controlled transmission power in an optimum manner. 5G millimeter wave (mmwave) communication system atmospheric attenuation is majorly caused by oxygen and water vapor gases out of various atmospheric gases [3-7].

This paper is organized as follows: Section II describe the 5G millimeter wave (mmWave) frequency spectrum communication system . Section III describe the Atmospheric Attenuation Due to Water Vapour and Oxygen in 5G Millimeter Wave (mmWave) Communication System. Further section IV describe the Software Defined Radio (SDR) for Atmospheric Attenuation Control in 5G Millimeter Wave (mmWave) Communication System .

II. 5G MILLIMETER WAVE (MMWAVE) FREQUENCY SPECTRUM

5G Millimeter Wave (mmWave) carrier frequencies allow for higher bandwidth and accordingly able to provide high speed internet data connection. 5G Millimeter Wave (mmWave) carrier frequencies have the low wavelength and leads to high attenuation and which requires signification study to decide the frequency bands. 5G Millimeter Wave (mmWave) can suffer with various type signal effects like attenuation, shadowing, Doppler effect , interference and etc. Federal Communications Commission (FCC) has recommended 5G Millimeter Wave (mmWave) carrier frequencies and bands to have research and development. The 5G Millimeter Wave (mmWave) carrier frequencies and bands are [8-11]:

- 28 GHz Band
- 37 GHz Band
- 39 GHz Band

For the above mentioned 5G Millimeter Wave (mmWave) carrier frequencies atmospheric attenuations is calculated and discussed in the following sections.

III. ATMOSPHERIC ATTENUATION DUE TO WATER VAPOUR AND OXYGEN IN 5G MILLIMETER WAVE (MMWAVE) COMMUNICATION SYSTEM

For 5G Millimeter Wave (mmWave) carrier frequencies , atmosphere gaseous losses are majorly due to the oxygen and water absorption bands. A formula for calculating predicting atmosphere gaseous absorption due to atmospheric gases oxygen and water vapor is mentioned by in ITU-R Recommendation P.618 . To calculate the gaseous attenuation due to oxygen and water vapor gases, the parameters are required for 5G millimeter wave (mmwave) communication system [3-7, 12-14]:

- 5G Millimeter Wave (mmWave) carrier frequencies
- Water vapor density for Delhi (India) based location
- Elevation angle
- Altitude (above sea level) for Delhi (India) based location and etc.

The total atmospheric attenuation for Delhi (India) based location is calculated by summing the absorption contributed by atmospheric water vapour and atmospheric oxygen . For Delhi based 5G Millimeter Wave (mmWave) Communication System water vapour density/ concentration is 10g/m3 Gaseous absorption is calculated as the sum of water vapor absorption and Oxygen absorption. The software defined radio (SDR) atmospheric attenuation calculation method is based on ITU model which is applied with 5G millimeter wave (mmwave) communication system for Delhi (India) based location [1-3, 13-17].

Figure 1 shows the effect of oxygen to millimeter wave (mmwave) propagation in different frequencies. Figure 2 shows the effect of water vapor to millimeter wave (mmwave) propagation in different frequencies. The molecules resonance of water vapour absorption takes place at approximately 22 GHz and 183 GHz, . Further absorption resonances for oxygen occurs at 60 GHz and 120 GHz. It is clear that the minimum attenuation occurs between these frequencies. It is shown in the figure that the Minimum attenuation occurs for the 28 GHz, 37 GHz and 39 GHz frequencies.

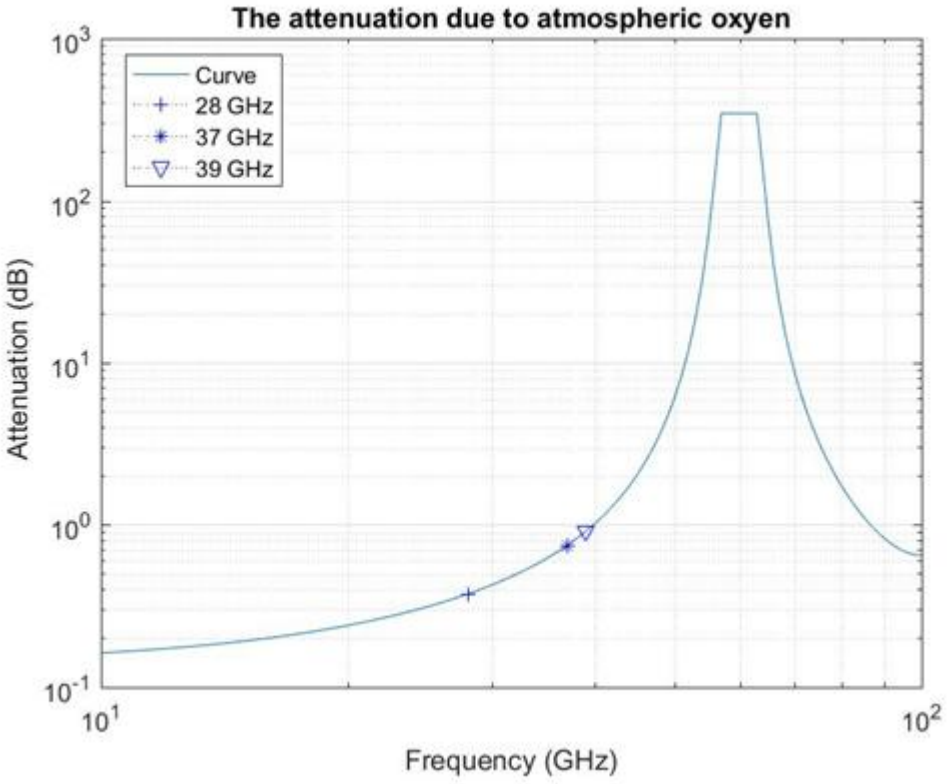

Figure 1: The attenuation due to atmospheric water vapour 5G millimeter wave (mmwave) communication system

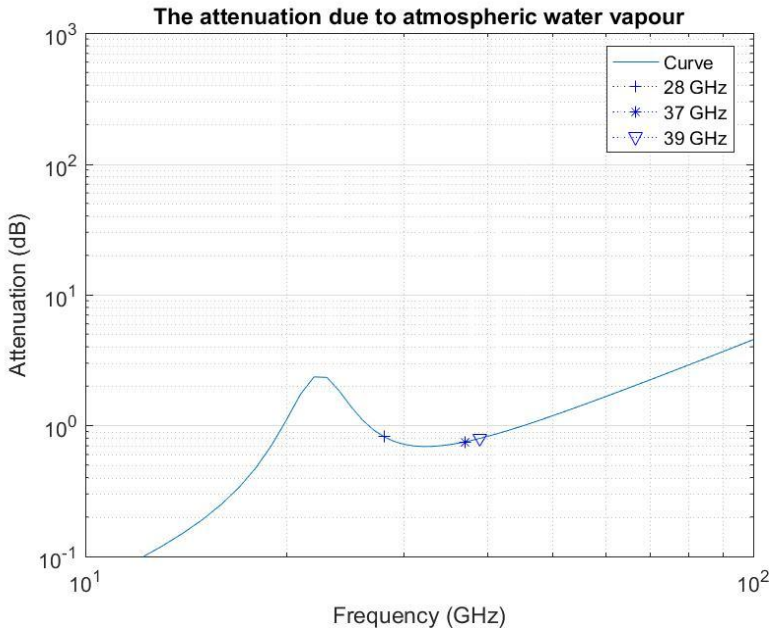

Figure 2 : The attenuation due to atmospheric oxygen 5G millimeter wave (mmwave) communication system

Figure 1 and Figure 2 show the 5G millimeter wave (mmwave) communication system atmospheric attenuation curve for the varied frequency in GHz. It is clear from the above figures that the atmospheric path loss is less for the frequencies 28 GHz, 37 GHz and 39 GHz. It also verifies the reason of having frequencies 28 GHz, 37 GHz and 39 GHz for 5G millimeter wave (mmwave) communication system.

Table 1 shows the atmospheric attenuation values due to water vapour and oxygen. The table 1 shows the attenuation values for the frequencies 28 GHz, 37 GHz and 39 GHz. The software defined radio atmospheric attenuation is calculated in real time using processors of SDR for Delhi (India) based location in 5G millimeter wave system.

Table 1: The atmospheric attenuation values for the frequencies 28 GHz, 37 GHz and 39 GHz due to water vapour and oxygen

Attenuation (dB)	Frequency 28 GHz	Frequency 37 GHz	Frequency 39 GHz
Aw *(due to atmospheric water vapour)*	0.8200	0.7500	0.7983
Ao *(due to atmospheric oxygen)*	0.3756	0.7495	0.9157

IV. SOFTWARE DEFINED RADIO (SDR) BASED ATMOSPHERIC ATTENUATION CONTROL IN 5G MILLIMETER WAVE (MMWAVE) COMMUNICATION SYSTEM

Software Defined Radio (SDR) system provides facility for parameters control at the end of the transmitters and receivers in the 5G Millimeter Wave (mmWave) Communication System . SDR can be used to implement digital signal processing (DSP) along with the below mentioned functions also [18-20]:

- Air interface
- Channel access
- Waveform synthesis
- Transmission power control and etc.

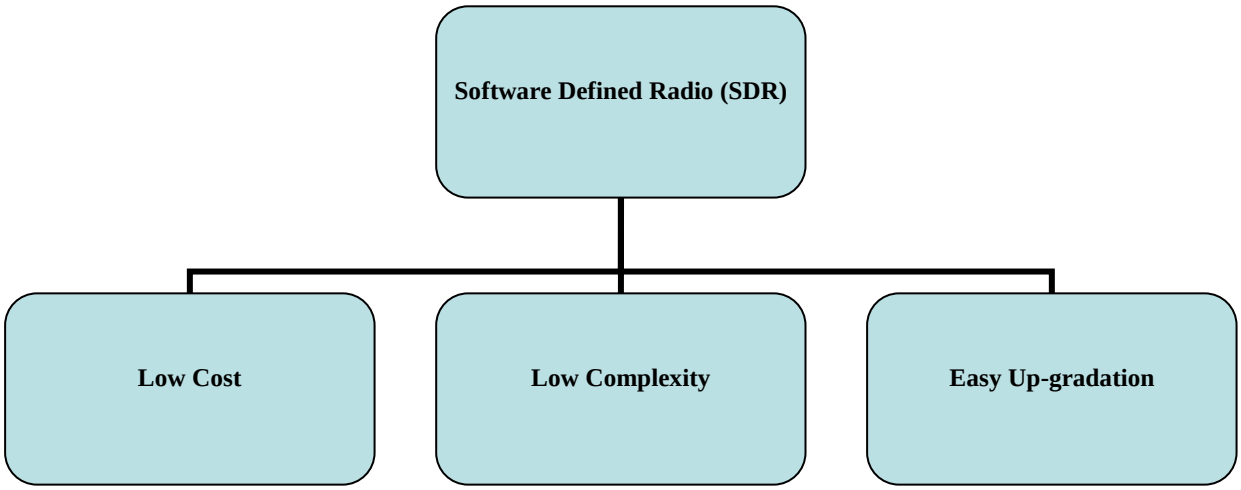

Figure 3: Features of Software Defined Radio (SDR) in 5G Millimeter Wave (mmWave) Communication System

SDRs provides optimum methods to control the transceiver as per demand and need of 5G Millimeter Wave (mmWave) Communication System . By having SDR based real-time reconfigurable processors , 5G Millimeter Wave (mmWave) Communication System can control transmission power and gain efficiently. SDRs is capable to provide variable and adaptive coding, decoding, modulation and radio access formats. It also reduces the cost, complexity and easy up-gradation as per technology update as shown in figure 3. SDR supports complex hardware functions easily in the software modules for the complicated functions like beam processing, array processing, precoding , interleaving and secure protocols and etc [18-20].

TABLE 3: The atmospheric attenuation values for the frequencies 28 GHz, 37 GHz and 39 GHz

Attenuation (dB)	Frequency 28 GHz	Frequency 37 GHz	Frequency 39 GHz
Aw *(due to atmospheric water vapour)*	0.8200	0.7500	0.7983
Ao *(due to atmospheric oxygen)*	0.3756	0.7495	0.9157
At *(Total atmospheric attenuation due to water vapour and oxygen)*	1.1956	1.4995	1.7140

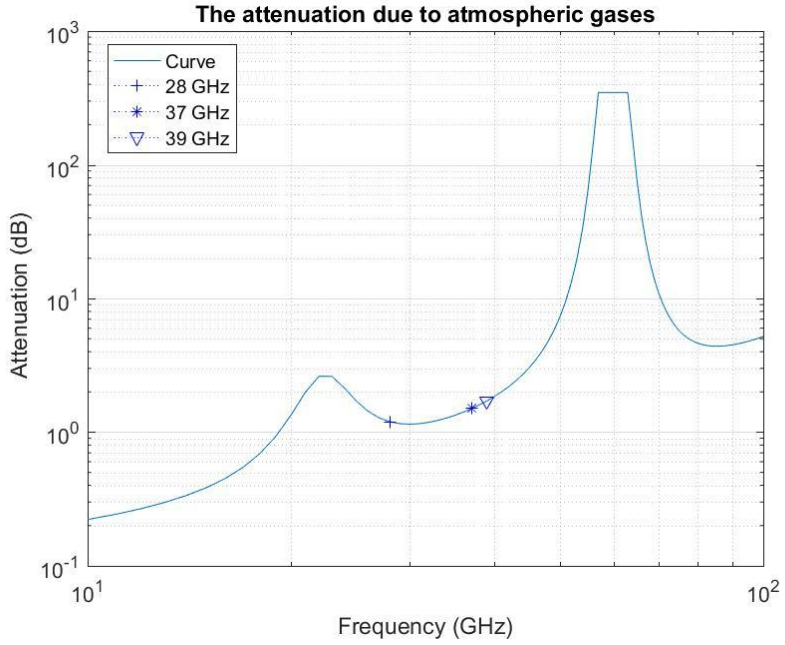

Figure 4 : The attenuation due to atmospheric gases 5G millimeter wave (mmwave) communication system

As shown in table 3 and figure 4 total atmospheric attenuation is sum of the absorption due to atmospheric water vapour and atmospheric oxygen. The table 3 along with figure 4 shows the attenuation values for the frequencies 28 GHz, 37 GHz and 39 GHz. It is clear that the atmospheric attenuation is quite less at the frequencies 28 GHz, 37 GHz and 39 GHz. The software defined radio atmospheric total attenuation is calculated in real time using processors of SDR for Delhi (India) based location in 5G millimeter wave system.

In the context of various atmospheric conditions due to change in atmospheric water vapour and oxygen level the transceiver power must be reconfigurable to have compensated power . Software defined radio (SDR) for in 5G Millimeter Wave (mmWave) Communication System compensates the transmitted power and gain due to Atmospheric Attenuation and transmits the software controlled transmission.

V. CONCLUSION AND FUTURE WORK

This paper presented atmospheric attenuation calculation for 5G millimeter wave (mmWave) propagation absorption at the frequencies 28 GHz, 37 GHz and 39 GHz for Delhi (India) based location using software defined radio (SDR). It is shown in the paper that the atmospheric attenuation varies and depends on the millimeter wave (mmWave) frequencies. It also shows the reason of the selection of the frequencies bands 28 GHz, 37 GHz and 39 GHz for 5G Millimeter Wave (mmWave) Communication System due to low atmospheric absorption in these bands. The model in this paper allows future realistic modeling of propagation conditions for millimeter wave transmission in urban microcellular environments.

This research paper shows the importance and consideration of the atmospheric attenuation due to atmospheric water vapour and atmospheric oxygen during transmission link budget for 5G Millimeter Wave (mmWave) Communication. The paper suggest that the 5G Millimeter Wave (mmWave) Communication devices shall consider additional transmission gain to compensate for the atmospheric attenuation or path loss to provide optimum signal strength at the receiver end. Future work involves the identifying the various other causes for the atmospheric attenuation for 5G Millimeter Wave (mmWave) Communication and handling with high flexibility and high efficiency through SDR .

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