Wasit Journal of Engineering Sciences

Journal homepage: https://ejuow.uowasit.edu.iq

The Effects of Different Weather Conditions on 5G Millimeter Waves Propagations at 38 GHz and 73 GHz for Kut-City in Iraq

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Received
31-December-2021
Revised
6-April-2021
Accepted
24-April-2022

Doi:
10.31185/ejuow.Vol10.Iss2.274

Abstract

It is critical to utilize a good model for predicting acceptable and optimum frequencies while designing and planning for the future generation wireless communications system's channel. This paper explains how the weather conditions affect the strength of the transmitted signal in various environments and circumstances, as well as how the mmWave behaves as it passes through free space and the atmosphere. An NYUSIM simulator package is used for predicting the performance of the channel for two months (January and July). Two frequencies were used, 38 GHz and 73 GHz to test the channel performance and which frequency is the best suited for the Kut city environment. The simulation results shown that an agreement with the 38 GHz for its lower path loss and acceptable received power. The weather database was real and actual obtained from the Iraqi meteorological organization and seismology reports consist of (rain, fog and temperature). The result for both directional and omnidirectional power delay profile showed a great agreement at 38 GHz for the two months (January and July), where the path loss and received power at 38 GHz for January is 127 dB and -47.2 dBm respectively, where for 73 GHz the path loss is 135.4 dB and with a received power of -55.7 dBm. At July the path loss and received power for 38 GHz and 73 GHz is (123 dB, -43.2 dBm) and (130 dB, -43.2 dBm) respectively.

Keywords: Weather condition effects, atmospheric attenuation, NYUSIM, mmWave

الخلاصة: تعتبر الموجات المليمترية واحدة من الركائز الأساسية لتكنولوجيا الجيل الخامس ، يوضح هذه البحث تأثيرات الظروف الجوية على قدرة الإشارة المرسلة في البيئات والسيناريوهات المختلفة وكيف تتصرف الموجات المليمترية تحت تأثير العديد من العوائق أثناء انتقالها عبر الفضاء الحر والجو. تم استخدام نموذج محاكاة ال (NYUSIM) للتنبؤ بأداء القناة لترددين هما 38 جيجاهرتز و 73 جيجاهرتز وذلك لغرض معرفة التردد الافضل و المناسب لمدينة الكوت حسب ظروفها الجوية. ان البيانات التي تم استخدامها في المحاكاة هي بيانات حقيقية من الانواء الجوية العراقية تشمل (المطر و الضباب و الحرارة). اظهرت نتائج المحاكاة قبولا للتردد 38 جيجاهرتز وذلك لانخفاض خسائر المسار (القناة) و قدرته المستلمة ضمن المستويات المقبولة. في شهر يوليو ، كانت القدرة المستقبلة عند 38 GHz لكل من الأرسالين الاتجاهي ومتعدد الاتجاهات 43.2 dBm و - 87.7 dBm على التوالي ، بينما بالنسبة إلى 73 GHz حيث تكون الطاقة المستقبلة هي 50.2- و93.5 - dBm. لذلك فإن 38 GHz تتمتع باستقبال طاقة أعلى من 73 GHz. حيث كانت الطاقة المتلقاة الاتجاهية ومتعددة الاتجاهات في شهر يناير عند 38 GHz هي 47.2 dBm - و 91- dBm ، وعند 73 GHz كانت 55.7- dBm و 98.9- dBm على التوالي.

1. INTRODUCTION

mmWaves are wide range of spectrum, ranging from 30 to 300 GHz, also have a wavelength between 10 to 1 mm. The mmWave also called the Extremely High Frequencies (EHF) [1]. With the increasing requirements for the high-speed radio links and the failure of the vast frequency band during the standard spectrum, that's why it's so urgent for a higher microwave and mmWave spectrum, at a very high frequency greater than 30 GHz. mmWave provides a wide range of benefits and applications for fifth-generation communications systems due to abundant spectrum available at mmWave frequency bands above 24 GHz which can offer highest capacity, ultra-high throughput and ultra-low latency, as a result from these properties, mmWave provides extensive applications like; it could be utilized for transferring huge types of data, mobile communications, also it is used for the high speed internet.[2], more applications and other benefits that provided by the mmWaves for the fifth generation nowadays are shown in Figure 1 [3]:

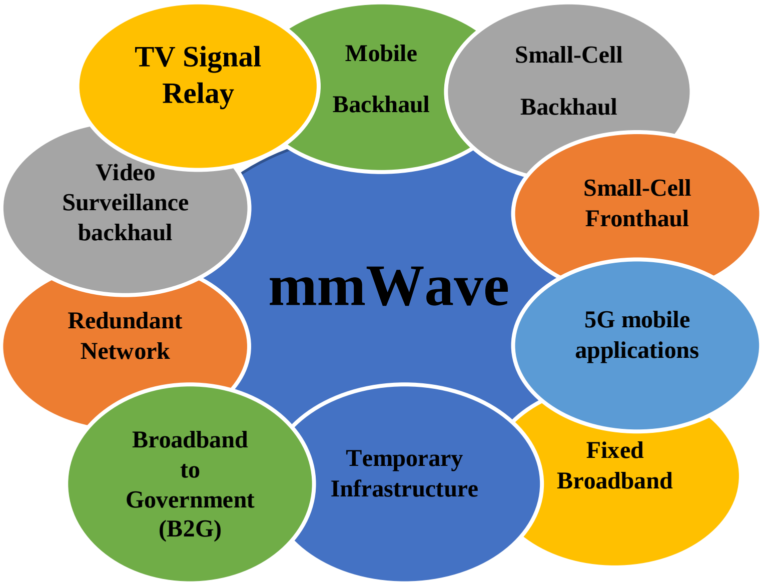


Figure 1 mmWave Applications and Use-cases

The atmosphere absorption, with the propagation mechanism effect, is one of the major concerns today. Rain, fog, and water vapour are causing some issues and difficulties. Each difficulty has a varied effect on the frequency, as well as the propagation path losses and the power received, at varying rates. It will also induce scattering, reflection, and diffraction, among other propagation processes, as shown in Figure 2 [4].

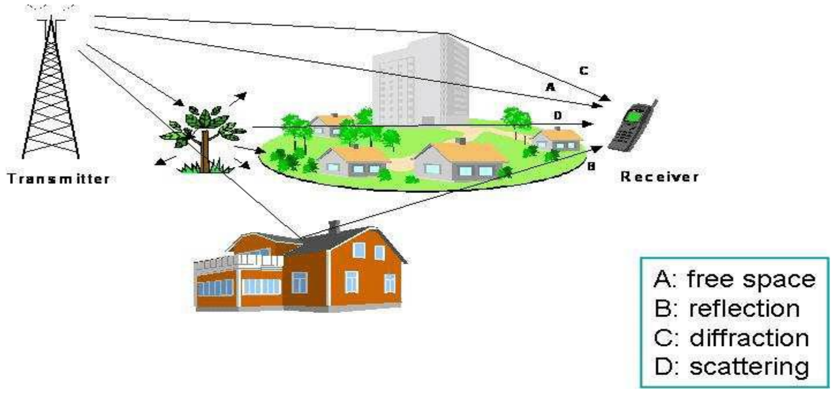


Figure 2 Reflection-Refraction-Scattering-of Electromagnetic waves

Each of the propagation mechanisms effects occurs under specific conditions: firstly, the scattering occurs when the propagation wave impinges on hard or erratic surfaces with more than an impediment, secondly, the reflection occurs when the signal hits a smooth surface with a large wavelength compared to the wavelength of the signal-wave, such as buildings and the earth, and finally, diffraction occurs when the signal or wave impinges on a smooth surface with a large wavelength compared to the wavelength of the signal.

This paper aims to investegate the channel performance under the effect of various weather conditions to build an effective fifth-generation communications network.

To maitain the aim of the paper; some objectives are presents like,

1. Building an effective 5G network MATLAB and the new york university simulator (NYUSIM) to.
2. The study highlights how the variations in atmospheric condition limits the performance of mmWave transmissions in Kut city for the two mmWave frequency bands (38 GHz and 73 GHz).
3. Two Simulation Packages are used in this paper which are A NYUSIM and MATLAB program to investigate the channel performance, path loss , received power and attenuation.

2. LITERATURE SURVEY

In reference [5] The impact of atmospheric barriers on mmWave based on long-distance telephone services; had been studied in [5]. The authors had evaluated the effects of sedimentation, mist, and air absorption on diffuse mmWave using the MATLAB tool. The goal of [6] was to give a quick overview of how atmospheric variables affect mmWave propagation, notably the blended attenuation induced by rain rate, mist, water vapour, and oxygen. Finally, it was discovered that modifying a channel that contains a big quantity of data and concepts is crucial for the better propagation of fifth-generation wireless communication. In [7] the visibility of 28 GHz and 73 GHz for outdoor communication has been investigated, with the help of specific scenario based on Statistical Spatial Channel Model (SSCM). The simulation results showed a small variation in each of coverage distance, path loss in addition to other factors. The final results cleared that in general both frequencies (28 and 73 GHz) are acceptable for the new fifth-generation system. The article in [8] had discussed the characterization of the fifth-generation channels at mmWave by using the NYUSIM package in Iraq and specifically in Baghdad city. The simulation results showed how would the variations of atmospheric conditions impacting the performance of mmWave propagation. In [9] the suitable and optimal of fifth-generation wave frequencies for Baghdad-City were discussed. The study uses a NYUSIM package to predict how the channel will react under the weather condition, specifically for two months (July and January). They used two frequencies (28 and 73 GHz). Final result showed an agreement to 28 GHz in both two months. The article in [10] was discussed the use of the statistical channel modelling and MIMO antennas for mmWave for 28 GHz and 73 GHz frequency bands. The study takes into account the impacts of weather conditions like rain, temperature and humidity, and simulates the Angle of Arrival (AoA) and Angle of Departure (AoD), Power Delay Profile (PDP), path loss and power loss. The authors concluded that; both 28 GHz and 73 GHz are suitable for the new 5G system in general.

All of the reviews above looked at the impact of atmospheric impairments on mmWave for a specific situation and environment, as well as specific frequencies, using a variety of approaches. In this paper, the NYUSIM package was analysed and the software was ran using real data from Iraqi Meteorological Organization and Seismology reports, which few previous studies had done. Finally, the effect of weather on the network was investigated, and the perfect frequency for Kut-City was determined in order to construct an effective 5G network with lower path loss, attenuation, and received power.

3. WEATHER CONDITION EFFECTS

Some key ideas in mmWave propagation research must be understood, in order to analyze the effect of the atmosphere on the mmWave during its propagation in free space, like:

i. The Environment, losses from gaseous,rain and other parameters.
ii. The Losses are larger at spesific frequencies, which correspond to the gas particles' (geometrical profile resonant) frequency.
iii. For the purpose of forecasting mmWave propagation profiling’s; both the water vapor and oxygen resonances have been analyzed vastly.
iv. Rain is the main concern when it is considered in the designing of 5G mmWave networks, because of the higher rain ratecauses higher path loss and attenuation, also the path loss increase as the frequency gets higher.

There are three main weather conditions tha thave an effect on mmWave propagation, which are; rain, fog, and gases In the following sub sections we will discuss the role of these conditions.

3.1.Propagation loss due to rain

The atmospheric path loss only explains the side of signal attenuation that occurs while traveling in a vacuum, while in practice; the signal will interact with air molecules and lose some of its energy as it travels via the diffusion path. Rain is one of the most serious issues that mmWave diffusion faces. The attenuation owing to rain is greater at frequencies higher than 100GHz, as seen in Figure 3 in [5]. The higher mmWave frequencies are not suitable for outdoor communications, and the higher the rainfall, the greater the attenuation.

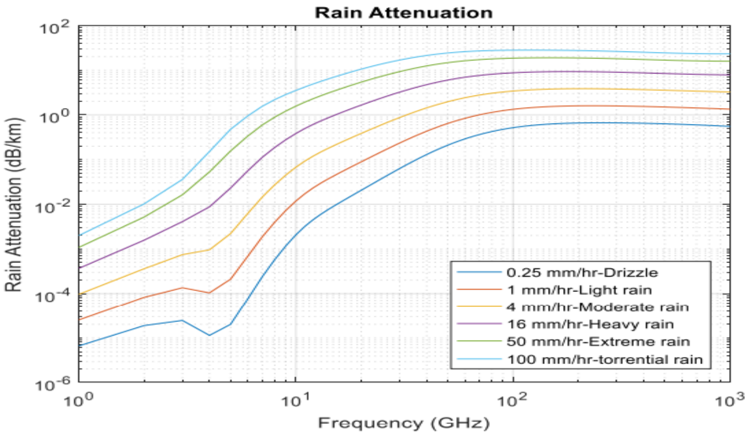


Figure 3 Rain attenuation dB/Km [5]

3.2.Propagation loss due to FOG

Fog and cloud are both made up of water droplets, but the size of the droplets is much smaller than that of raindrops. Fog droplets are typically smaller than 0.01 cm in diameter. Fog and cloud have fairly limited effects. According to studies, as the density of liquid water increases, attenuation increases as well, as illustrated in Figure 4 in [5].

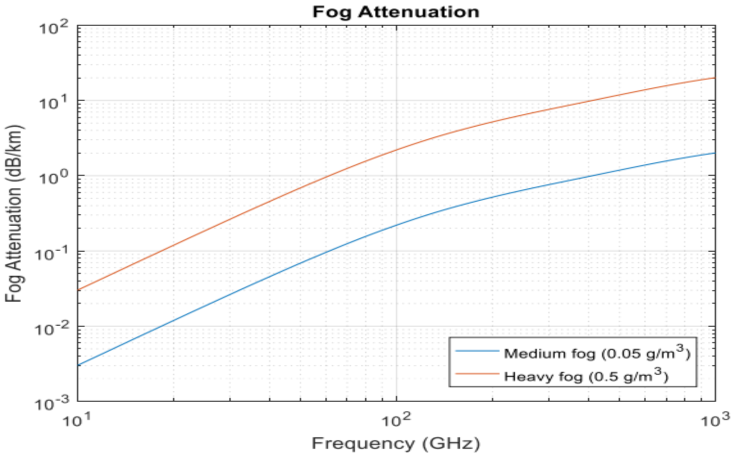


Figure 4 Fog attenuation in dB/Km [5]

3.3.Propagation loss due to GAS

The frequencies that are organized from 23 to 38 GHz as green circles in Figure 5 in, run into minor attenuation due to gas, demonstrating how productive mmWave communication is at such frequencies. The blue circles represent attenuation levels that are similar to attenuation in modern communication systems, and they appear larger than the green circles, and the red circles represent the frequencies with increased attenuation, indoor communication will be possible.

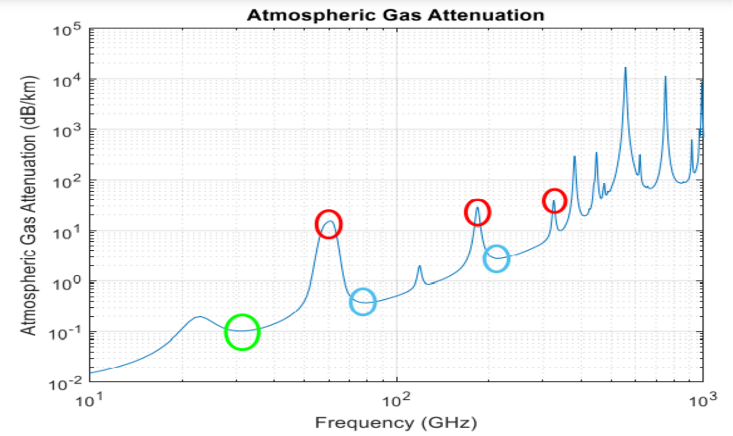
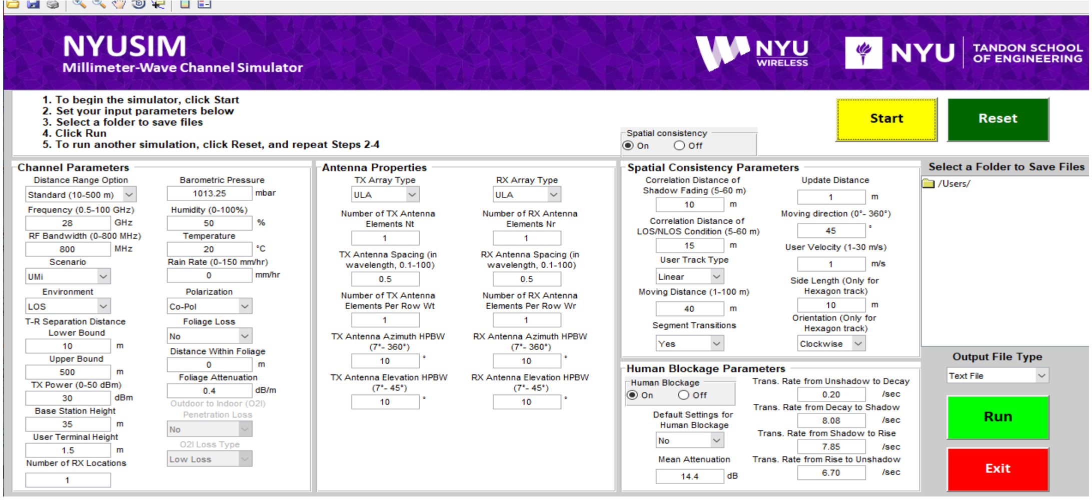


Figure 5 Atmospheric gas attenuation [5]

4. NYUSIM PACKAGE AND CHANNEL SUPPORTING

The New York University Wireless Group developed a channel model based on mmWave and established for frequencies ranging from 0.5 to 100 GHz. This model generates sample functions of the spatial and temporal Channel Impulse Response (CIR) from directional and omnidirectional channel models that are enhanced by NYUSIM wireless models and measurements [11]. There are two modes in the simulator: *Drop Based* and *Spatial Consistency*. Figure 6 shows a screenshot of the NYUSIM's Graphical User Interface (GUI). NYUSIM, which performs Monte Carlo simulations at specific separation distances between the transmitter and receiver, can generate Channel Impulse Responses (CIRs) taps.



1. To begin the simulator, click Start
2. Set your input parameters below
3. Select a folder to save files
4. Click Run
5. To run another simulation, click Reset, and repeat Steps 2-4

Spatial consistency ● On ○ Off

Channel Parameters

Distance Range Option: Standard (10-500 m)
Frequency (0.5-100 GHz): 28 GHz
RF Bandwidth (0-800 MHz): 800 MHz
Scenario: UMi
Environment: LOS
T-R Separation Distance Lower Bound: 10 m
Upper Bound: 500 m
TX Power (0-50 dBm): 30 dBm
Base Station Height: 35 m
User Terminal Height: 1.5 m
Number of RX Locations: 1
Barometric Pressure: 1013.25 mbar
Humidity (0-100%): 50 %
Temperature: 20 °C
Rain Rate (0-150 mm/hr): 0 mm/hr
Polarization: Co-Pol
Foliage Loss: No
Distance Within Foliage: 0 m
Foliage Attenuation: 0.4 dB/m
Outdoor to Indoor (O2I) Penetration Loss: No
O2I Loss Type: Low Loss

Antenna Properties

TX Array Type: ULA
Number of TX Antenna Elements Nt: 1
TX Antenna Spacing (in wavelength, 0.1-100): 0.5
Number of TX Antenna Elements Per Row Wt: 1
TX Antenna Azimuth HPBW (7°- 360°): 10 °
TX Antenna Elevation HPBW (7°- 45°): 10 °
RX Array Type: ULA
Number of RX Antenna Elements Nr: 1
RX Antenna Spacing (in wavelength, 0.1-100): 0.5
Number of RX Antenna Elements Per Row Wr: 1
RX Antenna Azimuth HPBW (7°- 360°): 10 °
RX Antenna Elevation HPBW (7°- 45°): 10 °

Spatial Consistency Parameters

Correlation Distance of Shadow Fading (5-60 m): 10 m
Correlation Distance of LOS/NLOS Condition (5-60 m): 15 m
User Track Type: Linear
Moving Distance (1-100 m): 40 m
Segment Transitions: Yes
Update Distance: 1 m
Moving direction (0°- 360°): 45 °
User Velocity (1-30 m/s): 1 m/s
Side Length (Only for Hexagon track): 10 m
Orientation (Only for Hexagon track): Clockwise

Human Blockage Parameters

Human Blockage ● On ○ Off
Default Settings for Human Blockage: No
Mean Attenuation: 14.4 dB
Trans. Rate from Unshadow to Decay: 0.20 /sec
Trans. Rate from Decay to Shadow: 8.08 /sec
Trans. Rate from Shadow to Rise: 7.85 /sec
Trans. Rate from Rise to Unshadow: 6.70 /sec

Select a Folder to Save Files

/Users/

Output File Type

Text File

Figure 6 Graphical User Interface

As seen in the GUI of Figure 6, the NYUSIM channel simulator requires 28 parameters for both channel and antenna setting. The GUI's panel antenna characteristics provide 12 input parameters for transmitter and reception antenna arrays, while propagation channel is included in the panel channel characteristics that need different input parameters [11]. In Table 1 an explanation for the legend of outputs simulation figures were presented.

Table 1 legend of the figures

Parameter	Definition
N	**Path Loss Exponent (PLE)**
Σ	**standard deviation of shadow fading**
Omni	**Omnidirectional**
dir	**Directional**
dir best	**the path with the most power received**
Pr	**Received power**
PL	**Path loss**

5. METHODOLOGY AND PROCEDURE

The methodology surveyed and followed in this study involved of the following tasks:

1. First of all, weather conditions of Kut city were collected from the weather reports for two diffrenet months (January and July). The mean minimum and maximum temperatures in Kut city were 5.8˚ and 48˚ respectively.
2. The effect of weather condition, Rain, fog and gas are presented. Real data measurement were used.
3. Then two frequencies were chosen for the simulator which is 38 and 73 GHz respectively.
4. A NYUSIM were used for measuring the channel performance under various weather conditions.

The data was entered for each month (January and July) and the program was ran, which in turn extract 5 Figures for each run, they are depict directional/omnidirectional power delay profile, Angle of Arrival (AoA) power spectrum, Angle of Departure (AoD) power spectrum and path loss power dely profile.

6. SIMULATION RESULTS

After setup the necessary parameters in the GUI of the NYUSIM, the parameters are as shown in Table 2 and Table 3 for two months, January and June respectively. The results for 38 and 73 GHz were obtained after running the channel simulator for the two months in section 6.1 and section 6.2.

6.1.January results

Figure 7 and Figure 8 shows the directional and omnidirectional Power Delay Profile (PDP) for Urban Microcell (UMi) scenario in Line of Sight (LoS) environment were the separation distance of 300 m at 38 GHz and 73 GHz respectively.at. The PDP depicts the signal's intensity as a function of time delay over a multipath channel, and the channel response appears as a series of pulses that can be used to derive channel properties such as delay spread. In omnidirectional measurements, there are three peaks, which indicate three multipath taps, while directional measurements have four peaks, which represent four multipath taps, as illustrated in Figures 7 and 8. Table 2 contain all of the parameters needed to build this PDP.

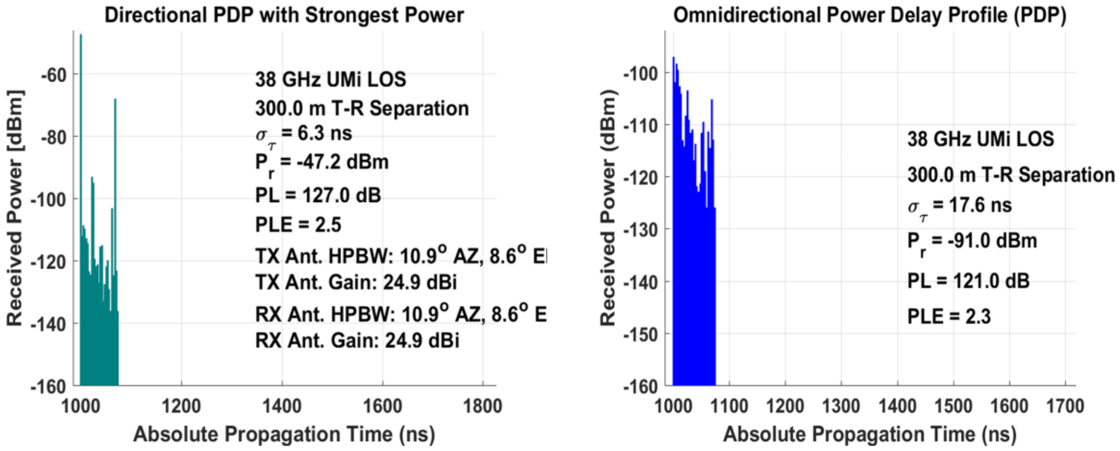


Figure 7 Directional and Omnidirectional PDP at 38 GHz for month of January

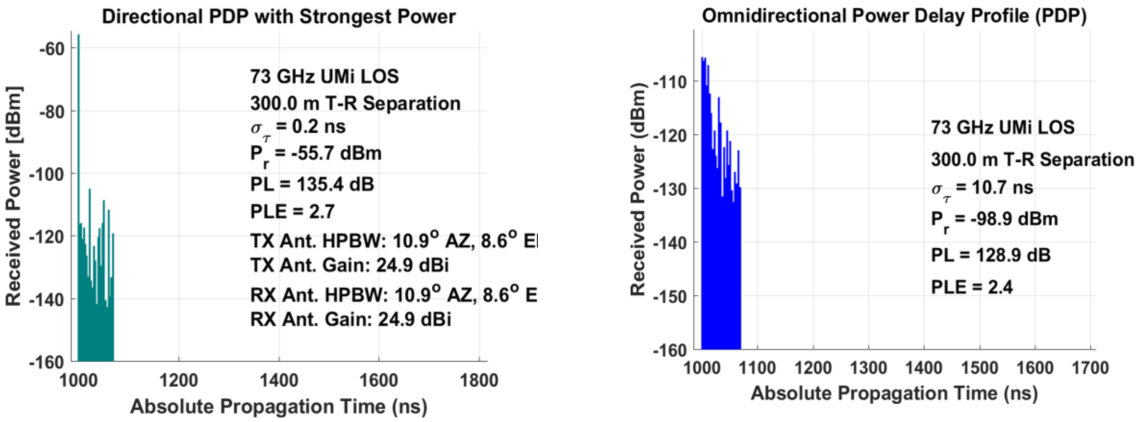


Figure 8 Directional and Omnidirectional (PDP) at 73 GHz for month of January

Table 2 Input parameters for January

Parameter	Selected value	Parameter	Selected value
Amount of Power Transmitted (P_t)	**30 (dBm)**	**HPBW RX antenna elevation**	**8.6°**
Polarization.	**Co-Polarization.**	**Pressure at the surface of the earth**	**995 (mbar)**
Scenario.	**UMi**	**Temperature**	**5.8° C**
The quantity of RX locations .	**1**	**Humidity**	**85%**
Type of array TX.	**ULA**	**rate of precipitation**	**44.3(mm/ hr)**
HPBW TX antenna azimuth	**10.9°**	**Environment**	**LOS**
HPBW.RX antenna azimuth	**10.9°**	**Bandwidth**	**800 (MHz)**
HPBW.TX antenna elevation	**8.6°**	**Frequency**	**38 & 73 (GHz)**

From Figures 7 and 8 it can be seen that the path loss and the received power at 38 GHz is better than that at 73 GHz, also for both frequencies the directional PDP has the best values of power received, but its path loss results is higher when compared to omnidirectional PDP. The best simulation results were shown at directional PDP for 38 GHz, where the received power result was -47.2 dBm and the path loss was 127 dB.

As a function of time delay, the "PDP" describes the density of a received signal via a multipath channel. Time delay, on the other hand, refers to the difference in travel time between multilane arrivals. The omnidirectional Channel Impulse Response (CIR) in Figures 7 and 8 is generally utilized to depict the radio propagation channel between the transmitter and receiver and can be expressed as in equation (1).

$$h_{omni}(t,\Theta,\emptyset) = \sum_{n=1}^{N}\sum_{m=1}^{M} a_{m,n} e^{j\emptyset m,n}\delta(t-\tau_{m,n})\delta(\varTheta-\varTheta_{m,n})\,\delta(\emptyset-\emptyset_{m,n}) \tag{1}$$

Where:

t = absolute propagation time

$\emptyset$ = $(\Theta, \emptyset)$_Rx= vectors of azimuth/elevation AoAs

Θ = $(\Theta, \emptyset)$_Tx= vectors of azimuth/elevation AoDs

n = number of time clusters (TC)

m= number of cluster sub paths

$a_{m,n}$ = amplitude of the m^{th} sub path belonging to the n^{th} time cluster

$\tau_{m,n}$ = propagation time delays.

$\varTheta_{m,n}$ = azimuth/elevation AoDs of each multipath channel (MPC)

$\emptyset_{m,n}$ = azimuth/elevation AoAs of each MPC

In Figure (7 and 8) by splitting the omnidirectional CIR to yield: the directional power delay profile (PDP) at a given Tx-Rx unique antenna-pointing angle, and for arbitrary Tx and Rx antenna equation can illustrated in equation (2).

$$\boldsymbol{h_{dir}(t,\Theta_d,\emptyset_d)=\sum_{n=1}^{N}\sum_{m=1}^{Mn} a_{m,n}e^{j\varphi m,n}\delta(t-\tau_{m,n})g_{TX}(\Theta_d-\Theta_{m,n})g_{RX}(\emptyset_d-\emptyset_{m,n})} \qquad (2)$$

$g_{TX}\left(\Theta_d-\Theta_{m,n}\right)$= arbitrary 3-D azimuth/ elevation Tx complex amplitude antenna patterns of multi-element antenna arrays

$g_{RX}(\emptyset_d-\emptyset_{m,n})$= arbitrary 3-D azimuth / elevation Rx complex amplitude antenna patterns of multi-element antenna arrays

Θ_d = required Tx antenna pointing angle

$\emptyset_d$ = required Rx antenna pointing angle

The three-dimensional Angles of arrival and departure are shown in Figures 9 and 10 for a single link between base station and user mobile in an Urban Microcell (UMi) scenario (which is an outdoor environment), Line of Sight (LoS), and T-R separation of 300 meters during January using 38 and 73 GHz.

The angle-of-arrival and angle-of-departure (AoA and AoD) spectra in Figures 9 and 10 depict the four multipath taps as four AoA and four AoD, respectively. These figures can be used to investigate how antenna beam widths affect the channel impulse response (CIR). NYUSIM provides three-dimensional plots to represent mmWaves propagating in a three-dimensional space, which is more practical.

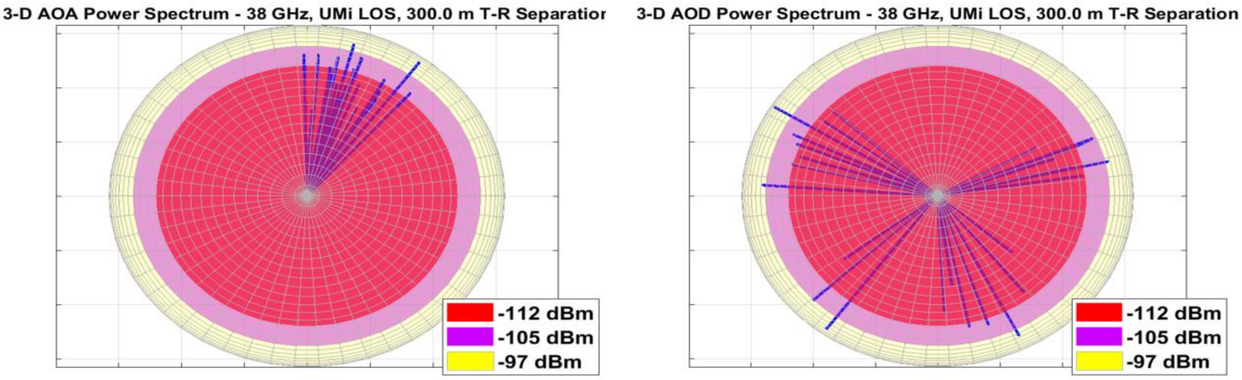


Figure 9 The 3D of AoD and AoA at 38GHz for January

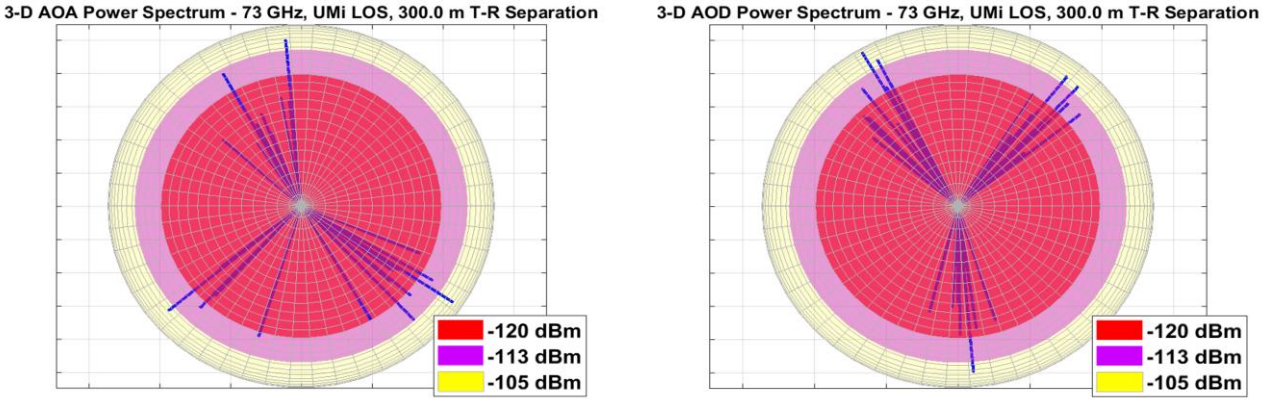


Figure 10 The 3D of AoD and AoA at 73 GHz for January

The AoA and AoD are determined as in equation (3).

$$H=\sqrt{\frac{M_{UE}M_{BS}}{P}}\sum_{P=1}^{P}\alpha_P\, a_{BS}(V_P)a_{UE}^{*}\,(w_p) \qquad (3)$$

where: H: is the channel finally, M_{UE}: is the user equipment antenna represented by w≜ sin (∅), M_{BS}: Is the base station antenna represented by v≜ sin(θ), a_{BS} & a_{UE}^{*}: the Array response vectors, V_P: The angle of arrival (AoA), w_p: the angle of departure (AoD) and P: the number of paths, α_P= stands for path gain.

Path loss is the measures of the power attenuation of an electromagnetic wave as it travels from transmitter to receiver in the presence of various atmospheric attenuators such as rain, dust, walls, and trees, among others.

Figure 11 and Figure 12 illustrate the directional and omnidirectional route losses, as well as the direction with the highest received power, for the two frequency bands 38 GHz and 73 GHz, respectively, at a separation distance of 300 m. The Path loss, and standard deviation of directional, Omni-directional, and the direction with the most received power are also shown.

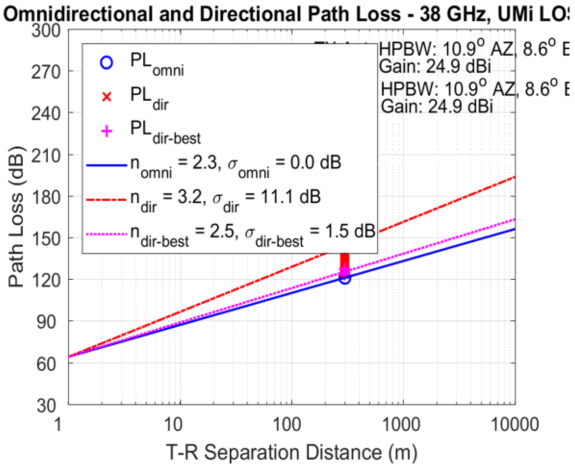


Figure 11 Directional and omnidirectional path loss at 38 GHz

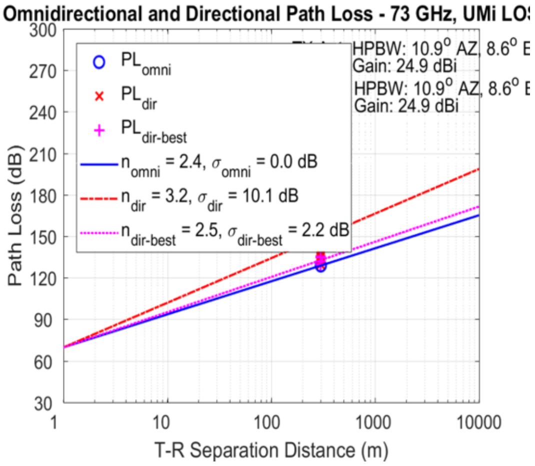


Figure 12 Directional and omnidirectional path loss at 73 GHz

6.2.July results

As shown in Table 3, various parameters were employed for the month of July with the identical scenarios (UMi) and in a Line-Of-Sight (LOS) environment as the month of January, with a separation distance of 300 m at both (38 GHz and 73 GHz).

Table 3 Input parameters for July

Parameter	Selected value	Parameter	Selected value
Amount of Power Transmitted (Pt)	**30 (dBm)**	**HPBW RX antenna elevation**	**8.6°**
Polarization.	**Co-Polarization.**	**Pressure at the surface of the earth**	**995 (mbar)**
Scenario.	**UMi.**	**Temperature**	**48° C**
The quantity of RX locations .	**1**	**Humidity**	**33%**
Type of array TX.	**ULA**	**rate of precipitation**	**0.0(mm/ hr)**
HPBW TX antenna azimuth	**10.9°**	**Environment**	**LOS**
HPBW.RX antenna azimuth	**10.9°**	**Bandwidth**	**800 (MHz)**
HPBW.TX antenna elevation	**8.6°**	**Frequency**	**38 & 73 (GHz)**

From the results shown in figures 13 and 14, also it can be seen that the 38 GHz frequency band shows a great performance when compare to 73 GHz frequency band, where the path loss at 38 GHz for directional and omnidirectional power delay profile (PDP) is 123 dB and 117.7 dB respectively, where for 73 GHz the path loss is 130 dB at directional (PDP) and 123.5 dB in omnidirectional (PDP). As it is shown; the directional (PDP) has higher path loss for both frequencies (38 and 73 GHz) when compared to omnidirectional (PDP). This is due to the effect of multipath components.

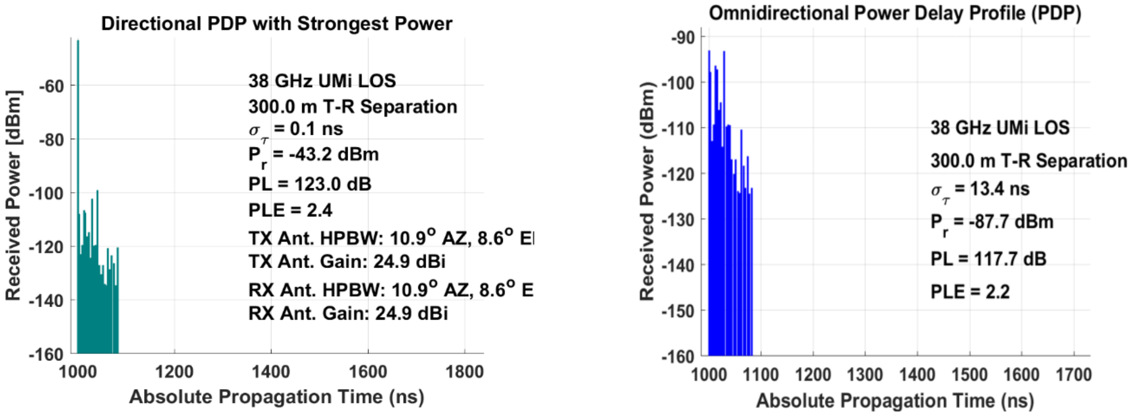


Figure 13 Directional and Omnidirectional (PDP) at 38 GHz for month of July

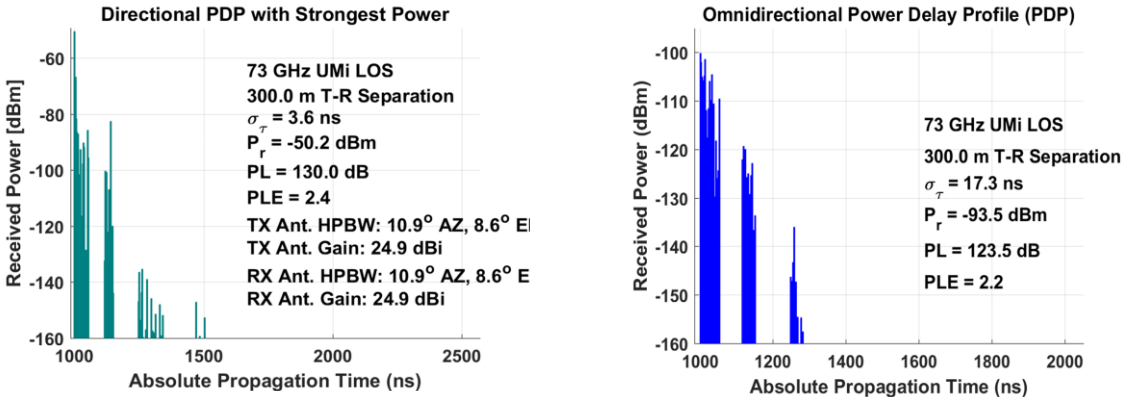


Figure 14 Directional and Omnidirectional (PDP) at 73 GHz for month of July

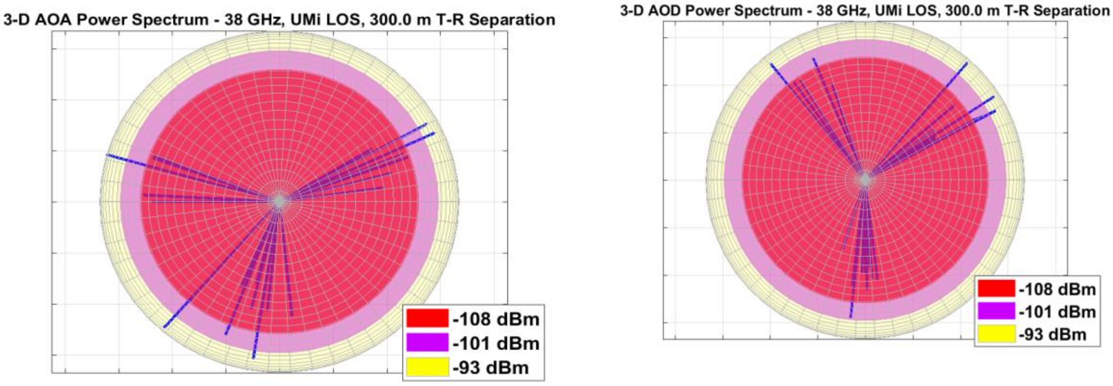


Figure 15 The 3D of AOD and AOA at 38GHz for July

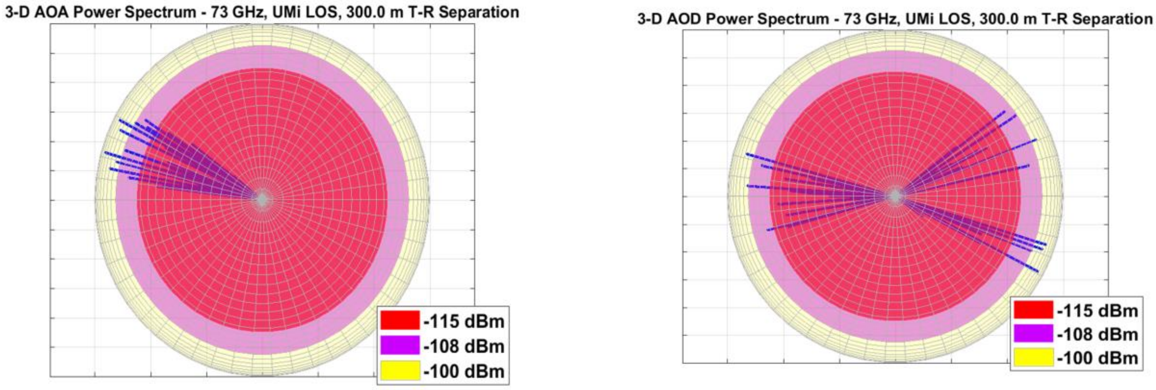


Figure 16 The 3D of AOD and AOA at 73 GHz for July

The angle-of-arrival and angle-of-departure (AoA and AoD) spectra in Figures 15 and 16 depict the three multipath taps as three AoA and three AoD, respectively. And its shown that the received power at 38 GHz is more than that at 73 GHz. The AoA and AoD power spectrum can be found as in equation (3).

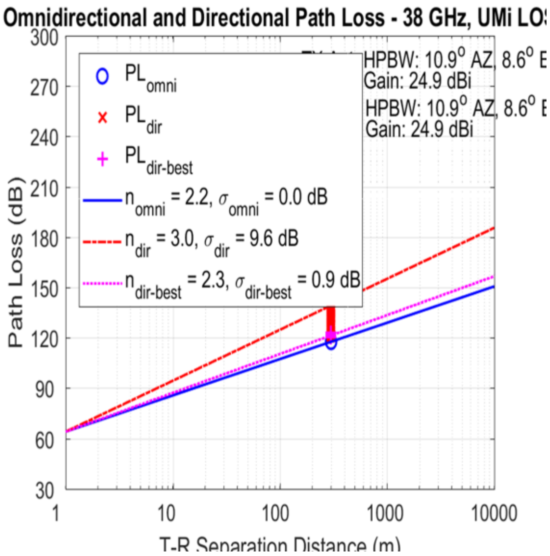


Figure 17 Directional and omnidirectional path loss at 38 GHz

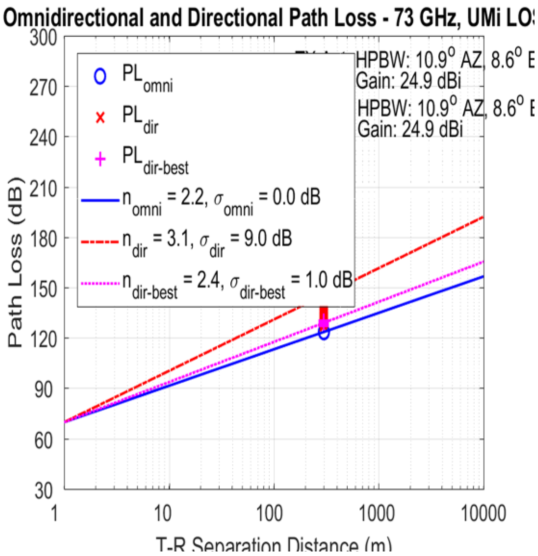


Figure 18 Directional and omnidirectional path loss at 73 GHz

Figures 17 and 18 shows the directional and omnidirectional route losses, as well as the direction with the highest received power, for the two frequency bands 38 GHz and 73 GHz, respectively, at a separation distance of 300 m. Path loss, standard deviation of directional, Omni-directional, and the direction with the most received power are also presented. from the figure it can be notice that the path loss for the 38 GHz frequency band is more less when compared to 73 GHz frequency band. When comparing between the two months (January and July); it is shown that January has the higher path loss than in July, this is due to the higher effect of rain on the signal propagation, which is considered as the main concern in mmWave transmission.

7. TOTAL SIMULATION RESULTS AND COMPARSION

Figure 20 shows the difference between the 38 GHz and 73 GHz in power received at 300 m at UMi scenario in LoS environment for January.

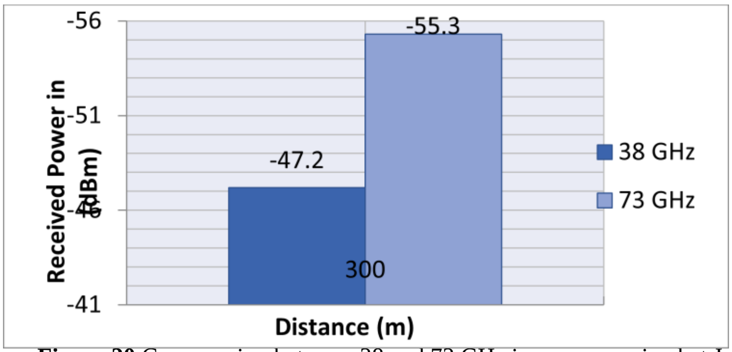


Figure 20 Compression between 38 and 73 GHz in power received at January

As shown in figure 20; the received power at the 38 GHz frequency band is better power than at 73 GHz frequency band.

Figure 21 shows the difference in path loss for 38 and 73 GHz. The 73 GHz frequency band has higher path loss than the 38 GHz. Figure 22 and 23 shows the difference in path loss and power received at 38 GHz and 73 GHz at July.

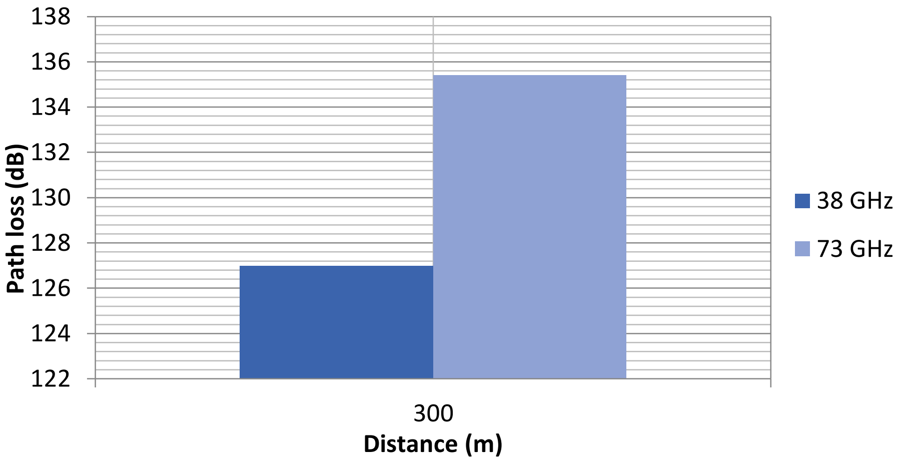


Figure 21 Compression between 38 and 73 GHz Path loss at January

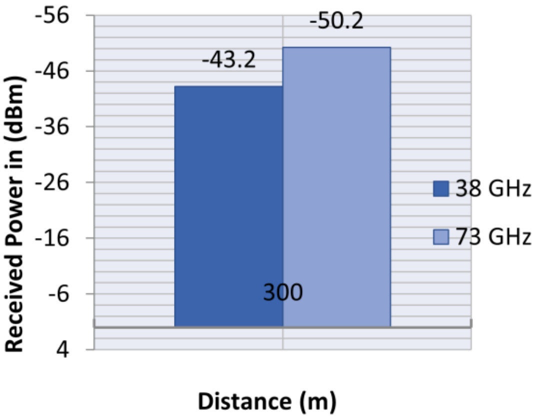


Figure 22 Compression between 38 and 73 GHz in power received at July

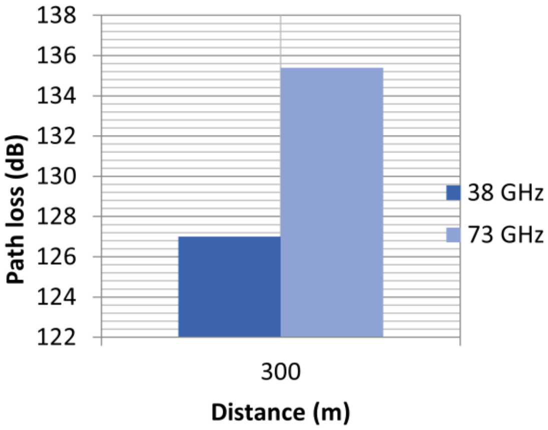


Figure 23 Compression between 38 and 73 GHz Path loss at July

8. CONCLUSIONS

In this paper, the impact of atmospheric conditions on the mmWave propagation in Al-Kut city environment were studied for two months (January and July), which represent the coldest and hotest months in Iraq respectively.

The weather data base used were real and taken from the Iraqi meteorological organization and seismology reports consist of (rain, fog and temperature) for the targeted city. A NYUSIM (NEY YORK Simulation) were used to verify channel performance under the variation of weather conditions, in addition to MATLAB program for the calculation of attenuation. This study could be considered as an important reference for the use of mmWave in the 5G network in Al-Kut city. Two frequencies were used (38 GHz and 73 GHz) for two months (January and July), Acording to simulation results; the path loss at 38 GHz in directional PDP for the both months (January and July) were 123 dB and 128 dB repectively, where in Onmidirectional PDP the path loss for the same months were 117.7 dB for July and 121 dB for January. The result show that the Omnidirectional PDP has lower path loss, this is because of the effect of multipath components. Where for 73 GHz the path loss was 128.9 dB at low temperature (January) and 123.5 dB at high temperature (July). From the simulation results it can be noticed that the rain has significant impact on the propagation of mmWave, which causes higher path losses and reduce the power received. Also The results show a great agreenment with 38 GHz frequency band for its lower path loss and the higher power received when comparted to 73 GHz. It can be conclude that the weather conditions (Rain, Fog and temperature) has huge effect on the performane of the channel specificly the Rain, in addition to the separation distance between the transmitter and receiver. This study is the first one for Al-Kut city in Iraq.where it states the problem and goal clearly to answer the challenges on technology development

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the Iraqi Meteorological Organization and Seismology for their support in providing as by the data on weather of Al-Kut city.

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