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The Enhancement of Horn Antenna as A direction Antenna for 5G Applications in mm-Wave Band

Ramdan Amter Mohamed
A. Awad Ahmed
University of Khartoum Department of electric and electronics engineering Khartoum Sudan

Email: ramdanamter64@gmail.com

Abstract:
It has introduced the growth of wireless broadband traffic significant impact on future mobile network architectures and it makes more demands including high traffic information capacity, increase internal small traffic, and large huge devices connected from point to point P to P. The adoption of highly directional antennas at mm-wave using horn antenna. The millimeter wave frequencies with horn antenna being planned for 5G systems pose challenges for channel modeling band. At this reaches 26 GHz used and 1GHz bandwidth. The antenna sector led to a promising solution concerning the enhancement of the network resources, extending the system at these bands, and guaranteeing enough resources to cope with the upcoming surge in mobile data traffic and provide more capacity to network and allow more connection. Array technique was used in this research to produce a high gain and directivity beam stream to cover the required area around the base station. CST software used in this reaches to describe the channel capacity, enhancing spectral efficiency, this strategy increases system performance. The high-directed beam shapes are designed and shown and steered to detect. Finally, the presented results are discussed.

الملخص:
نمو حركة المرور ذات النطاق العريض اللاسلكية لها تأثير كبير على أبنية شبكة الهاتف النقال في المستقبل، و تشمل علي المزيد من المطالب تشمل قدرة المعلوما ت المرسله، وزيادة حركة المرور الصغيرة الداخلية والكبيرة للأجهزة الضخمة المتصلة من نقطة إلى نقطة. اعتماد استخدام هوائيات المصفوفه الاتجاهيه باستخدام هوائي القمع غاية مفيده في نطاق ترددات المليمتريه. ترددات الموجات المليمترية مع هوائي القمع تشكل المخطط المطلوب لها لأنظمة الجيل الخامس في تحديات نطاق نمذجة القناة ، تم إقتراح استخدام التردد 26 جيجا هرتز وعرض النطاق الترددي 1 جيجا هرتز في هذه الورقه، لتسهيل عملية التقسيم والذي يؤدي الى حل واعد فيما يتعلق بتعزيز موارد الشبكة وتوسيع النظام في هذه النطاقات والذي يضمن توفير موارد كافية للتعامل مع الطفرة القادمة في حركة بيانات الهاتف المحمول وتوفير المزيد من السعة للشبكة والسماح بمزيد من الاتصال. استخدم برنامج CST للحصول علي اشكال من الشعاع الموجي وفرق الكسب ذات التوجيه العالي موضحا ذلك النتائج.

1- INTRODUCTION

A. General Overview

Today, the field of wireless mobile communications is the fastest growing and includes a wide range of technology areas. This has been proposed in recent years. Antennas for mobile communication systems are used and developed to overcome the problem of limited channel bandwidth, thereby meeting the ever-increasing demands on communication channels for a large number of mobile phones[1]. Numerous studies have shown that deploying arrays in cellular communication systems can improve system performance by increasing channel capacity and spectral efficiency, extending range coverage, adjusting beam shape, steering multiple beams to track multiple cellular phones, and electronically compensating for aperture distortion. multipath fading, channel interference, system complexity, and cost. Bit error rate and failure probability are also reduced. Adaptive antennas and the algorithms to control them are considered crucial for the development of high-capacity communication systems[2].
The mm-wave carrier frequencies allow wide bandwidth which increases the data transfer rate between mobiles and allows service providers to significantly expand the channel BW. The direction antenna using sectrization theory for 5G generation is a good promise to overcome the challenge in mobile networks. Fifth generation 5Gth is the current study of the mobile network, the compact designs of the antennas made it possible for them to resonate at a higher frequency, so 5G needs to transmit a high data rate and produce good multi-service for the mobile network[3, 4]. They are two types of sectroisation

a- Horizontal sectorization was used in the old generation to increase frequency reuse and improve network capacity.
b- Vertical sectorization has several advantages in the greeting network capacity and providing better coverage solutions for high-rise buildings.

B. Wireless Generation

Wireless generation is defined as changes in transmission technology and frequency bands over time, which are further divided into 1G, 2G, 3G, 4G, and 5G. Each generation has its own characteristics, strategies, and strengths that make it unique. Cellular technologies range from the first generation (1G) to the fifth generation (5G) (5thG). First-generation services include low-bit-rate mobile voice and data; second-generation services include low-bit-rate mobile voice and data; third-generation services include high volume data movement; fourth-generation services include high-speed technology and high mobility fifth-generation services Businesses include high bandwidth, large coverage mobile communication systems[3].

C. Challenges

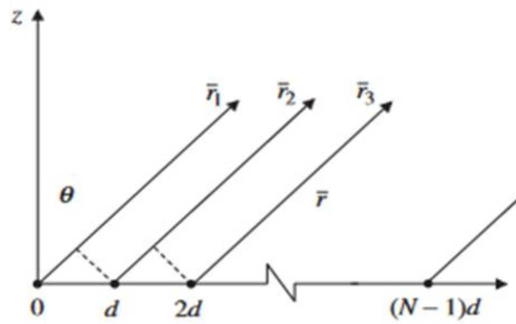
Adoption of the mm-wave band as a potential spectrum of 5G application requires a deep change mode to the network architecture due to different propagation conditions and hardware constraints. Due to the anticipate, increase in capacity, and increase in traffic and connectivity, the present backhaul Links of the network will not accommodate this huge traffic a new wireless backhaul link infrastructure is needed.

II. DIRECTIONAL ANTENNAS

Directional Antennas provide a narrow beam that allows highly directional propagation and is mainly used for point-to-point links and base station wireless systems, for example-waves, and sector antennas respectively [5]. Since the radiation power is focused in a particular direction it travels a longer distance thus providing a larger coverage area and excellent pathless with high antenna gain. At the transmitter side, a directional antenna concentrates transmitting signals in one direction, which leads to no interference or less interference with other transmissions. On the other hand, on the receiver side, a directional antenna can shield interference from other transmitters.

A-Base Station Array Antenna

The Base station antenna consists of a linear array with an N-element array. All elements are equally spaced and have equal amplitudes. Later we may allow the antenna elements to have any arbitrary amplitude. Figure 1 shows an N-element linear array composed of isotropic radiating antenna elements. It is assumed that the nth element leads the (n − 1) element by an electrical phase shift of δ radians. This phase shift can easily be implemented by shifting the phase of the antenna current for each element.



Figure(1):. Element of the Antenna

Assuming far-field conditions such that r d, we can derive the array factor as follows:

$$AF = 1 + e^{+j(kd\cos\theta+\beta)} + e^{+j2(kd\cos\theta+\beta)} + \ldots + e^{j(N-1)(kd\cos\theta+\beta)} \quad (1)$$

Where N is of elements in the array,k is the wave number which is qual $2\pi/\lambda$,d is the spacing between the elements, and θ is the angle between the array axis.

This series can more concisely be expressed by

$$AF = \sum_{n=1}^{N} e^{j(n-1)(kd\sin(\theta+\delta))} = \sum_{n=1}^{N} e^{j(n-1)\psi} \quad (2)$$

Where $\psi = kd\cos\theta + \beta$

From figure 2 phase shift θ for two mobile terminals can be determined as follow

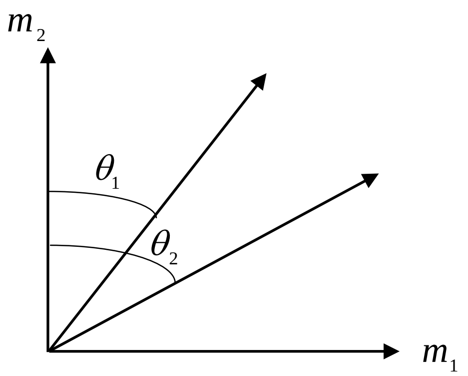


Figure.(2): Phase shift θ for two mobile terminals

if $\alpha 1 - \alpha 2 \leq \theta c$

$$\theta = \frac{\alpha 1 - \alpha 2}{2} \quad (3)$$

Where

α_1 : the angle of the mobile terminal (1)

α_2: the angle of the mobile terminal (2)

θ_2 : the critical angle between two mobile

then AF can be written as follows

$$AF = \sum_{n=1}^{\frac{N}{2}} e^{j(n-1)(kd\sin(\theta_1))} + \sum_{\frac{N}{2}}^{N} e^{j(n-1)(kd\sin(\theta_2))} \quad (4)$$

Due to the mobile terminal mobility, the direct Angle between the antenna and the mobile (α) changes with a value of (Δα) which depend on the random speed of the mobile[1, 6] terminals Then if $|\theta - \theta_N| < \frac{\theta_N}{2}$

The new-looking angle of the antenna can be calculated as follows

$$\theta_N = \frac{(\alpha_1 + \Delta\alpha_1) - (\alpha_2 + \Delta\alpha_2)}{2} \tag{5}$$

$$\theta_N + \frac{\phi}{2} \geq \theta_{max} \tag{6}$$

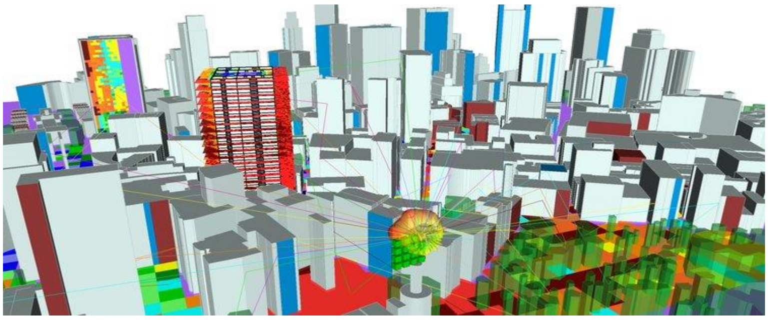
Where ϕ : is the beam width
θ_{max} is the maximum looking angle of the antenna.

III. MICROWAVE CELLS SPLITTING

One especially type of directional antenna is the horn antenna which has a high gain directivity and narrow beam width to produce a directional beam forming pattern.
Now used in mm-wave to take advantage of its characteristics. with no interference between paths. Since the majority of communication systems use the mm-wave band. This makes mm wave too tight. In the mobile communication network, the base station is expected to use millimeter wave frequency. The operating band of the 5G mobile station is (20-90) GHz This step is a big revolutionary because the mm-Wave band is very different propagation conditions, atmospheric absorption, and hardware limitations. However, such challenges may compensate with beamforming and a larger antenna array[7, 8].
The used mm-Wave must be passable in a small limited cell radius <500 m to decrease high path loss (by moving the access point closer user). Fortunately, this move works well for intensive Fortunately, this action fits well with the dense deployment of small cells which will be the trend of next-generation mobile systems [9]. As per our model, a small cell with high order sectorisation is considered as shown in figure.3; the coverage of the small cell area is divided equally by the sectorisation[10, 11].

A. 5G Urban Small Cells

Urban small cells are one of the most challenging scenarios for simulation of performance for 5G. Network densification, whether for increased capacity or to deal with millimeter wave propagation challenges, leads to much more complex urban multipath conditions, as shown in figure 4. Wireless small cells provide a unique ray-tracing solution that not only captures the detailed multipath, but also enhances this with an accurate prediction of the spatial variation of fields, polarization, and phase, even over small scales across a millimeter wave directional array antenna, offering a unique capability for predictive simulation[12, 13].



Figure(4): Outdoor mmWave Planning various positions of urban

B - Horn antenna model

The millimeter waves frequencies being planned for 5G systems pose challenges for channel modeling. At these frequencies, surface roughness impacts wave propagation. The transmitter is modeled using a horn antenna pattern with 15° beam width and 20 dBi gain that is rotated to point at each receiver location. Sectrorisation increases the capacity of a cellular system since it increases the number of times that channels are reused, and These techniques are a three-sectored solution [12, 14].

The models used in this research are simplified and simple to calculate the optimal dimensions. figure 5. Shows a horn antenna where a and b are the horn dimension in H-plain and E-plain .where a=28mm, b=58mm A=100 mm and B=100 mm. The beam –treeing in azimuth (Y axis) was chosen to obtain the side lobe to cover the 120^{o} sector.

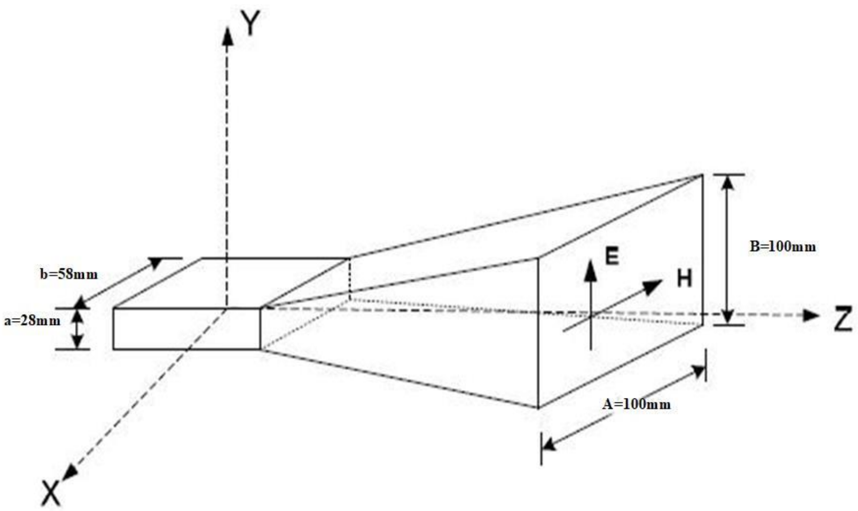


Figure (5): Horn Antenna with dimensions for the base station final design

From the cross-section of figure 5, the calculation procedure is as follows at frequency 26 GHz, and Using the equation from (7) to (10) the slant lengths and Aperture lengths can be calculated by:

$$\left.\begin{aligned} L_E &= \frac{b_{12}}{8\lambda\rho 1} \\ L_{H} &= \frac{a_{12}}{8\lambda\rho 2} \end{aligned}\right\} \tag{7}$$

$$\left.\begin{aligned} A_E &= \sqrt{2\lambda}L_E \\ A_{H} &= \sqrt{2\lambda}L_H \end{aligned}\right\} \tag{8}$$

The directivity (in dB) of a horn, can also be approximated by

$$D_P(dB) = 10\left[1.008 + \log_{10}\left(\frac{a_1 b_1}{\lambda^2}\right)\right] - (\mathrm{L}_E + \mathrm{L}_H) \tag{9}$$

lengths and Aperture lengths can be calculated by equations

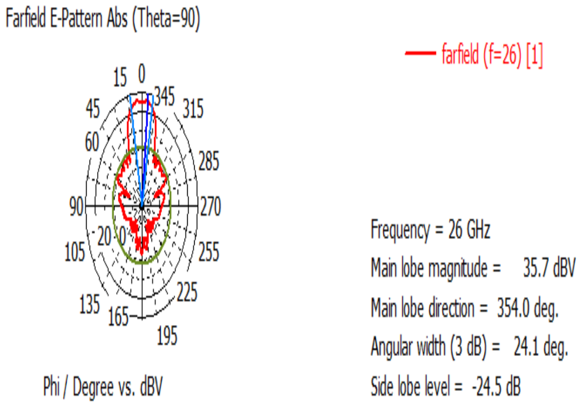
$$\left.\begin{aligned} X &= \frac{a}{\lambda}\sin\theta\cos\phi \\ Y &= \frac{b}{\lambda}\sin\theta\sin\phi \end{aligned}\right\} \tag{10}$$

$$E_\phi(\theta) = \pi^2\cos\theta\frac{\cos\left(\frac{\pi a}{\lambda}\sin\theta\right)}{\pi^2 - 4\left(\frac{\pi a}{\lambda}\sin\theta\right)^2} \tag{11}$$

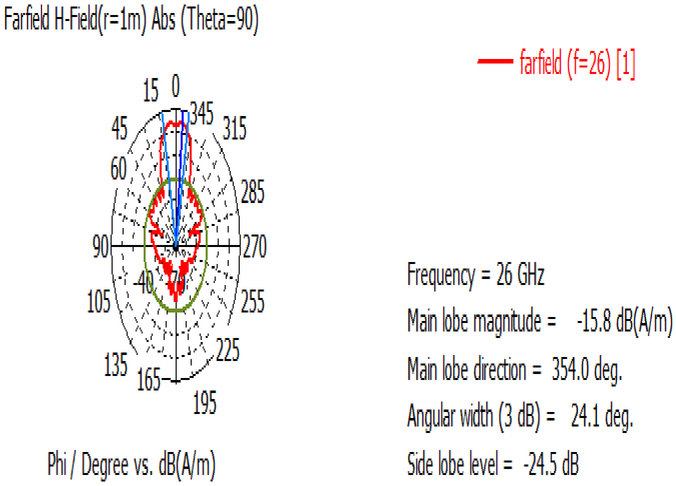
$$E_\theta(\theta) = \frac{\sin\left(\frac{\pi b}{\lambda}\sin\theta\right)}{\frac{\pi b}{\lambda}\sin\theta} \tag{12}$$

IV. Simulation and results

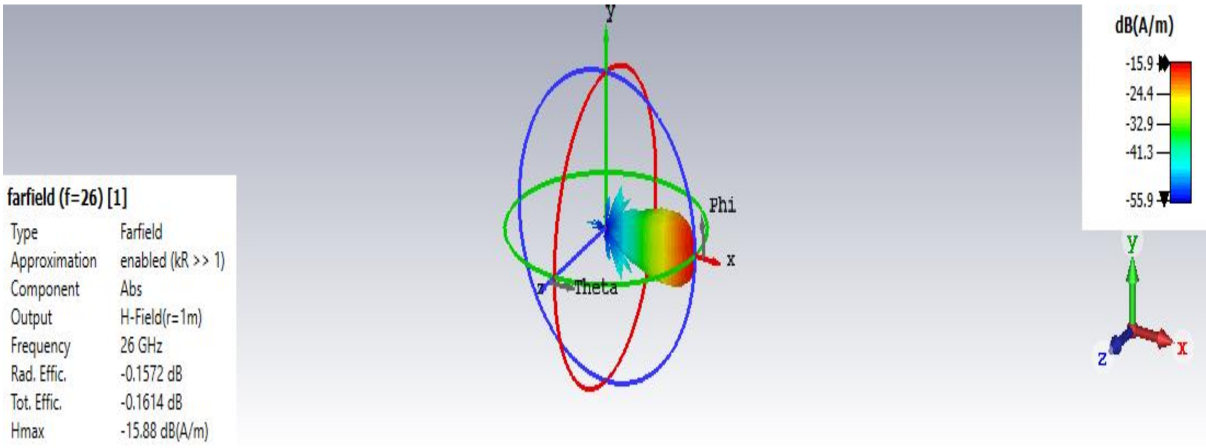
In this paper computer CST Studio software[12].is used to design horn antenna according to the above calculation, diffuse scaring capability, to perform simulation of wireless network compares to some measurement detailed. This software result handles many different scenarios of analytical patterns and can also utilize important patterns. Figure 6, Figure 7 Demonstrations the Fairfield E-pattern and H-pattern respectively at frequency 26GHz with main lobe 35 dB and side lobe -24.5 dB, and -15.8 dB, side lobe -24.5 dB. Figure 9 shows good directivity of an antenna at beginning of simulation at 26 GHz with main lobe magnitude =21dB and side lobe -24.5 dB. The gain of the antenna is an important characteristic because the directivity refers to the gain if the gain has increased the directivity also increased, the more strong signal will be radiated from the horn antenna figure 10 show the gain of the antenna at 19 GHz, 26GHz and 30GHz



Figure(6) : farfield E-pattern at frequency 26 GHz



Figure(7): farfield H-pattern at frequency 26 GHz



Figure(8): Radiation pattern of horn antenna

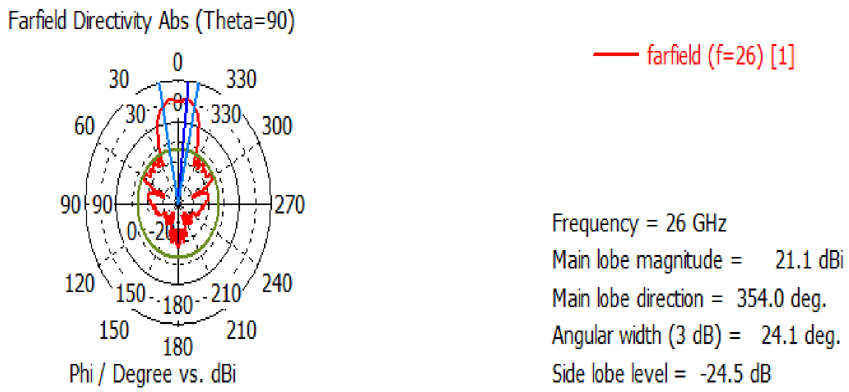


Figure.(9): Farfield directivity at frequency 26 GHz

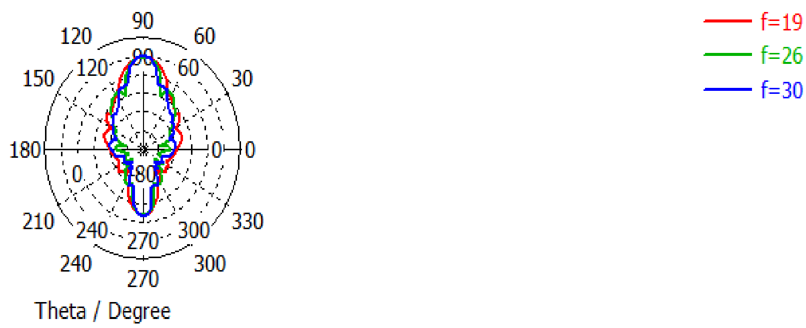


Figure.(10): Gain (IEEE) at constant phi=0 for 5×5 array(array factor)

V. Conclusion

This paper has presented important results such as H- plain and E-plain directed array antenna systems. A Horn antenna was designed and used in the simulation results show a radiated pattern in mm-wave at a frequency of 26 GHz. Good results for directivity and gain that can be interested in the future 5G technology. This paper provides an example of the feasibility of antennas at these mm-wave frequencies with reasonable accuracy.

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