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Design and Analysis of Phase Array Antenna for 5g Applications

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Abstract - The antenna configuration for the upcoming 5G mobile communications should meet specific features like the compact size in which it makes it suitable for supporting high bandwidth, more gain, and perform multiple input multiple output spatial multiplexing and beamforming to obtain their benefits and to tame their limitations.
Keywords - 5G, MIMO, mm Wave, Phased antenna array, HFSS.

I. INTRODUCTION

Phased array antennas have the unique ability to alter the shape and direction of radiation pattern without physical motion of antenna. Phased arrays have been implemented widely in different radars for providing beam streaming of radiated electromagnetic signals operating at same frequency. It offers a directional gain that is helpful in detecting weak targets and suppressing side lobe interferences from other devices.

The recent improvements in modern mobile communication domain have deficient frequency spectrum resource. Therefore, necessity for antennas seem difficult to attain6 the requirements of applications where cost, size and performance of antennas are major constraints. In such conditions, a low cost and robust antennas are essential. Hence, microstrip patch antennas and antenna arrays are commendable choice.

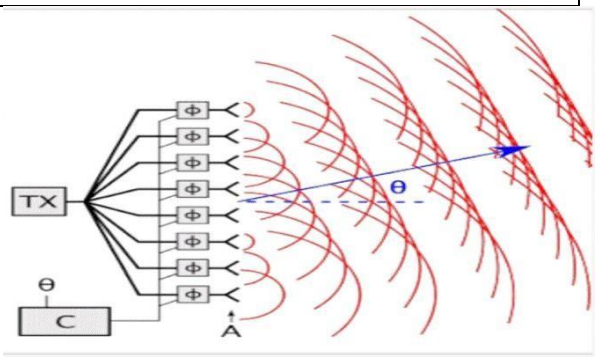


Fig 1: Animation of Phased Array Antenna

A. Phased Array Antennas

Two or more set of antennas are called antenna array to achieve the improved performance the signals from the antennas are combined or processed the antenna array can be used to increase the gain diversity reception from the particular set of directions it cancel out the interference. It is sensitive in a particular direction called steer and also it determines the direction of arrival of the incoming signals. Without any physical drift the phased array antennas will change the direction and shape of radiated signals this also have the attributes of electronic steering. The phased array antenna is the phase dependent superposition of two or more radiated signals where they are combined together to form a signal of additive amplitude the equal

quantity of work done by the group working together can achieve more than a single unit where the principles put through to accomplish improved signal strength, gain, directive and performance over discrete antennas.

II. MATHEMATICALMODELLING

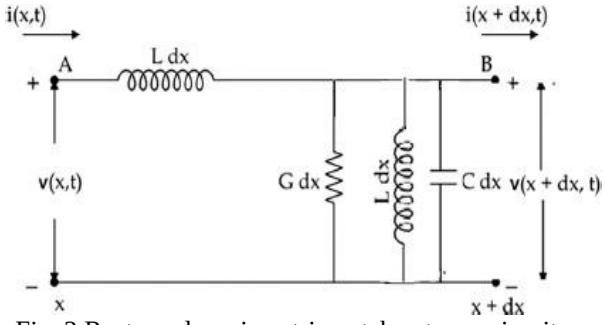


Fig. 2 Rectangular microstrip patch antenna circuit

A. Rectangular microstrip patch antenna

Here radiating metallic patch is situated on one side of a resistant substrate panel with a metallic ground plane deposit on the other side of the panel. Microstrip is in rectangular patch which seems like a trimmed microstrip communication line. It is approximately of one-half wavelength long. When air is used as the dielectric substrate, the length of the rectangular microstrip patch antenna is around one-half of a free-space wavelength. The antenna decreases as the relative dielectric constant of the substance increases. The length of a antenna is slightly tiny because of the extended electric.

B. Working of phased arrayantennas

Multiple emitters are used for beamforming in phased array antennas in a high frequency RF applications. Wi Fi, chirped radar and 5F are the three common applications area in phased array. The main goal of using the phased array antenna is to alter the direction of an discharged beam. It enables beamforming by regulate the signals sent to each emitter in the antenna array the radiation patterns are controlled and directed to target without any physical movement of antenas. Signals are ideally in the phase they produce intense radiation and beneficially where it happens in a specific direction and these directions are controlled by the phase shift between signals from the different emitters these are controlled by deposit a slight time delay between signals which are sent by the arrays during this process the intensity decreases the sidelobes existing in the beam are periodic also to get very strong beam in a definitedirection.

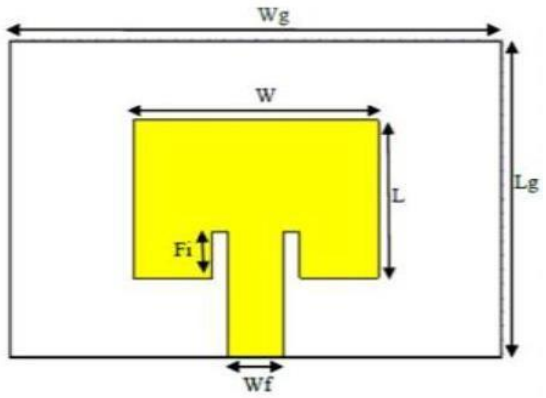


Fig. 3 HFSS design specifications

C. Wide scanningangle

The main purpose of the phased array antenna is to scan a wide range with high gain using as few antennas as possible the array pattern consists of the product of array factor and element pattern. The array pattern of a linear array antenna can be expressed as equation

$$Array\ Pattern = Element\ Pattern \times Array\ Factor = f(\theta) \times \sum_{n=1}^{N} e^{-j(n-1)(k_0 d \sin\theta - \Phi)}$$

Where, f is the element pattern, N is the number of antenna elements, k0 is the wave number, d is the element spacing, and Φ is the phase difference between elements.

In general, the scanning range of phased array antenna means 3 dB-coverage and is limited by the element pattern due to the relation. Here the antennas are capable of transmitting and obtaining wideband attributes that are high and will be operated at a high frequency range. The design issue are size depletion and bandwidth enhancement. The main focusing is on Multiple Input and Multiple Output antennas.

TABLE I
DESIGN SPECIFICATIONS

Parameter	Dimension (mm)
Ground Plane Length, L_g.	6.285
Ground Plane width, W_g.	7.235
Length of patch, L.	3.4
Length of width, W.	4.1
Height of substrate, h.	0.5
Width of feedline, W_f.	1.25
Feedline insertion, F_i.	1.25
Ground Thickness, t.	0.035

On the fabrication of 5G antennas no research detecting have been recorded. Hence the effect of thickness of the conductive material and the evolution of the mathematical model on a single element and the rectangular microstrip patch are operated at 28GHz for the communication

III. CALCULATIONS

The antenna and antenna arrays are designed using the transmission-line model. Based on this model, practical design procedure using the simplified formulas are described for the rectangular patch antennas. The antenna design procedure assumes that dielectric constant of substrate(),resonant frequency (f_r), and height of substrate (h) are known in prior. Patch Width(W)

$$W = \frac{1}{2f_r\sqrt{\epsilon_0\mu_0}}\sqrt{\frac{2}{\epsilon_r+1}}$$

Patch Length(L)

$$L = \frac{1}{2f_r\sqrt{\epsilon_{reff}}\sqrt{\epsilon_0\mu_0}} - 2\Delta L$$

where,

$$\epsilon_{reff} = \left(\frac{\epsilon_r+1}{2}\right) + \left[\left(\frac{\epsilon_r-1}{2}\right)\left(1+12\frac{h}{W}\right)\right]^{-0.5}$$

and

$$\Delta L = 0.412h\frac{(\epsilon_{reff}+0.3)\left(\frac{W}{h}+0.264\right)}{(\epsilon_{reff}-0.258)\left(\frac{W}{h}+0.8\right)}$$

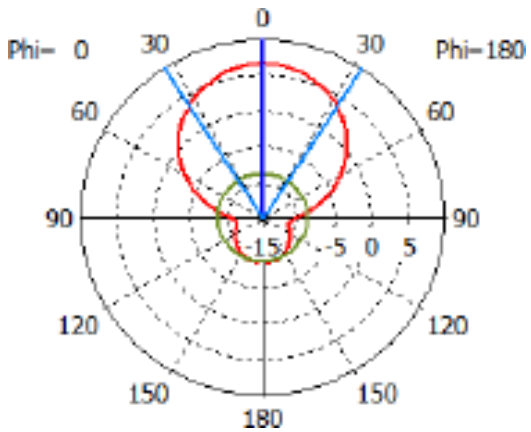
Effective patch length (Le)

$$L_e = L + 2\Delta L$$

L = Patch length extension □ = Relative direct constant

μ = Permeability in free space.

A common property of MPA is that besides the field radiated into space, as the antenna portion launches surfaces wave modes. The surface wave power will diffract from the edges of the substrate for finite sized substates, resulting in disturbances of pattern of radiation.



Theta/deg vs dB

Fig 4: Radiation Pattern

The radiation pattern is a mathematical function or a graphical structure of the far field the where it has the direction of departure of the electromagnetic wave

IV. SIMULATIONRESULTS

A. About Ansys HFFS software

Ansys HFFS is an electromagnetic structure from Ansys it stands for the high frequency structure simulator it is one of the several commercial tools used for the design of the antenna and also for the electronic circuit elements which includes filters, transmission lines and packaging. The HFFS was developed by the Prof. Zoltan Cendes and hisstudents.

S-Parameters[Magnitude in dB]

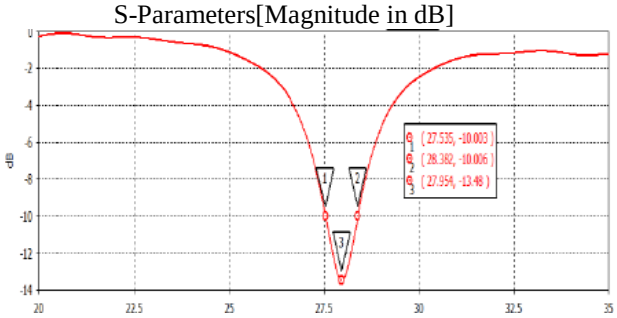


Fig 6: Return loss

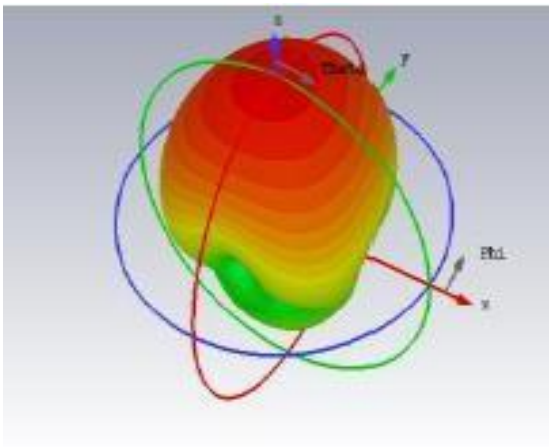


Fig 5: Simulation results in 3D

B. Advantages of phased arrayantenna

Power is the collective of signal which is summation of the separate signals powers and the strength is raised. Beamforming is where the shape of the beam can be adjusted by the difference between the individual signals and the radiation

pattern of phase array antenna. Beam steering is the eradication of mechanical reposition which makes the beam steering or beam positioning pliable. Cost can replaced by less expensive phased arrayantenna.

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