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PATCH ANTENNAS FOR MILLIMETER WAVE APPLICATIONS

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ABSTRACT:

Major advances in millimeter-wave antennas have been made in recent years, in particular in two areas – printed dipole antenna and patch antenna designs. Here a patch antenna for millimeter wave applications is designed. The designed structure of the antenna consists of four driven patches in four edges connected to the center patch. The antenna has the capability to work in the millimeter range. The range here taken is 90 to 95 GHz. The antenna is fed using a simple coaxial cable which is connected to the bottom patch.

Keywords:

Millimeter wave frequency, patch antenna, driven patch, 5G

1) Introduction:

The millimeter-wave region of the electromagnetic spectrum is commonly defined as the 30GHz to 300GHz frequency band or the 1cm to 1mm wavelength range. Utilization of this frequency band for the design of data transmission and sensing systems has a number of advantages. The very large bandwidth resolves the spectrum crowding problem and permits communication at very high data rates. The short wavelength allows the design of antennas of high directivity but reasonable size, so that high-resolution radar and radiometric systems and very compact guidance systems become feasible. Millimeter waves can travel through fog, snow, and dust much more readily than infrared or optical waves. Finally, millimeter-wave transmitters and receivers lend themselves to integrated and, eventually, monolithic design approaches, resulting in RF heads which are rugged, compact, and inexpensive.

In recent years patch antennas play a major role since they have attracted interest for microwave applications. Also they have created interest in millimeter range. This is because of their wide bandwidth, ease of fabrication, low cost and ease of operation. They also have potential for high energy operation. These kinds of antennas include studies, for instance, quasi yagi antennas, printed dipole antennas and angled dipole antennas. A quasi yagi antenna is proposed for active antenna arrays at X-band frequencies. Similarly printed dipole with coplanar feed is for Ka-band and angled dipole antennas is for phased array applications. These antennas can achieve multiband opearation but their disadvantage is they have a large size.

In this paper, we have proposed a planar patch antenna for use in millimeter wave application. We use a simple coaxial cable as a feed structure to energize the antenna. Coaxial line feed will avoid discontinuity, hence the antenna can work for a long period. The big patch is divided into five small patches to reduce power dissipation. Here the patch used is annealed copper which is a lossless metal. The substrate is ROGERS RT-5880. By increasing the width of the substrate it is possible to increase the bandwidth but the disadvantage is the size of the antenna will be huge. We use the electromagnetic simulator called CST - Microwave Studio (CST – MWS; Computer Simulation Technology AG., Darmstadt, Germany) for the simulations in this work.

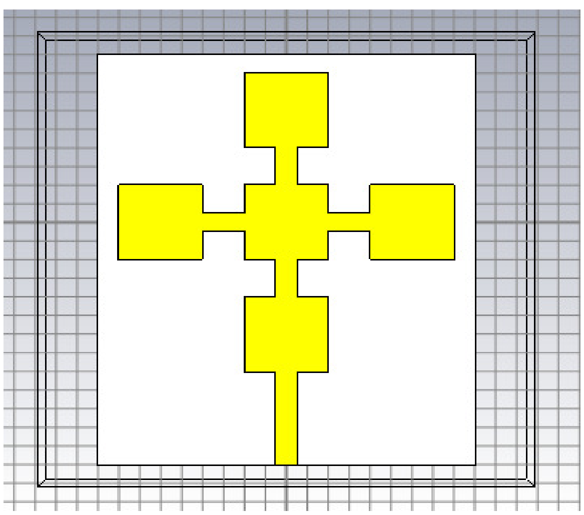

Fig 1: Design structure of the proposed antenna

2) Antenna Design and Characteristics:

The geometry of the patch antenna, which was designed on both sides of ROGERS RT-5880 with a thickness of 0.035 mm, permittivity 3.75. The antenna was composed of a 50 ohm microstrip line feed, a truncated ground plane, a coaxial line and a patch. The feed line is in the top of the substrate whereas the ground plane is in the bottom side of the substrate. The patch was fed by a short line with a characteristic impedance of 50 ohm. Here the ground and patch is made up of annealed copper and substrate is made up of a material called ROGERS RT-5880. ROGERS RT-5880 is a semiconductor made up of extrinsic combination of Indium, Gallium and Phosphate (InGaP). It has low dielectric constant hence less dissipation factor. It serves as an ideal candidate for broadband circuit designs which requires fast signal speeds or improved signal integrity.

In base paper, to achieve impedance matching over a broad frequency range, an integrated balun is used as a feeder. But it requires much space and also it leads to discontinuities in energizing the antenna. Hence to make it simple, a coaxial cable is used as a feed line. It is connected to the patch which is edged on the ground plane. Here the impedance matching is also achieved. The patch was embedded to achieve compact size. Also it is used to realize a wide pattern in E-plane. The antenna was characterized via CST Microwave Studio to ensure good impedance matching and good gain. The design parameters of the antenna are as follows: L_{gnd} - 18mm, B_{gnd} – 22mm, W_{gnd} – 0.035mm, L_{sub} - 18mm, B_{sub} – 22mm, W_{sub} – 1.6mm, L_{p1} - 2mm, B_{p1} – 2mm, W_{p1} – 0.035mm, L_{p2} - 2mm, B_{p2} – 2mm, W_{p2} – 0.035mm, L_{p3} - 2mm, B_{p3} – 2mm, W_{p3} – 0.035mm, L_{p3} - 2mm, B_{p3} – 2mm, W_{p3} – 0.035mm, L_{p4} - 2mm, B_{p4} – 2mm, W_{p4} – 0.035mm, L_{p5} - 2mm, B_{p5} – 2mm, W_{p5} – 0.035mm.

COMPONENTS	X_1	X_2	Y_2	Y_2	Z_1	Z_2
GROUND	-9	9	-13	9	0	0.035
SUBSTRATE	-9	9	-13	9	0.035	1.6
PATCH1	-2	2	-2	2	1.6	1.635
PATCH2	-2	2	4	8	1.6	1.635
PATCH3	-2	2	-4	-8	1.6	1.635
PATCH4	-4	-8	-2	2	1.6	1.635
PATCH5	4	8	-2	2	1.6	1.635
FEEDLINE1	0	1	-13	-8	1.6	1.635
FEEDLINE2	0	1	-4	-2	1.6	1.635
FEEDLINE3	2	4	0	-1	1.6	1.635
FEEDLINE4	0	1	2	4	1.6	1.635
FEEDLINE5	-2	-4	0	-1	1.6	1.635

Table : Design values in the proposed antenna

3) Results:

The below furnished details illustrate the simulated results of the antenna. The antenna is simulated using CST. The antenna parameters like reflection coefficient, radiation pattern and gain are given below.

3.1) Return loss:

The reflection coefficient (the return loss in db) is the fraction of the input power being returned back from the output port to the input port of the antenna. This coefficient does not give any idea of the remaining power which is radiated or dissipated. Hence it does not clarify whether the antenna is a good radiator or a bad radiator of electromagnetic waves. For a good antenna, the reflection loss should be less than -10db. The antenna is analysed in 90 to 95 GHz range using CST Microwave Studio. The antenna resonates at 92.8GHz giving a reflection loss of 24.32db. Also at 93.8GHz there obtained a reflection loss of 20.68db. The plotted curve shown in the figure below shows that the antenna covers the whole spectrum of 90 to 95GHz.

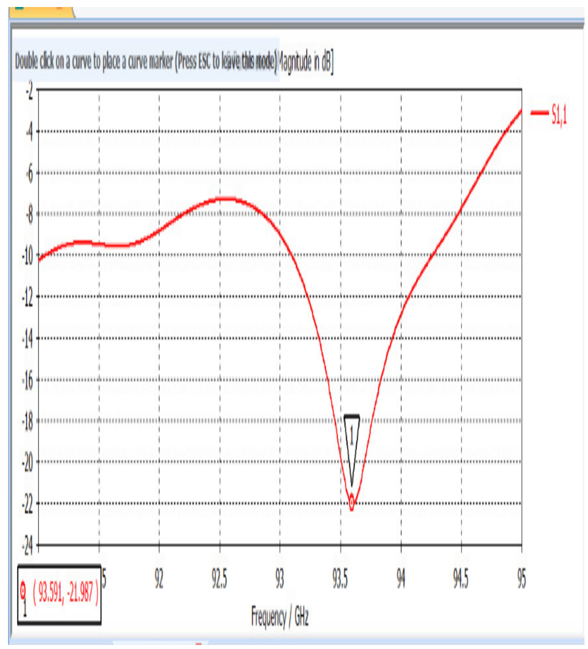

Fig 2: Return loss

3.2) Gain:

The gain of an antenna is defined as the logarithm of ratio of total power at the output to the input. Hence it determines how stable the antenna is. Also it determines the efficiency of the antenna. For a good antenna, the gain value should be of a positive value. High gain value denotes the antenna is more stable and hence less power dissipation. The antenna is analysed in 90 to 95 GHz using CST Microwave Studio. The antenna resonates at 95GHz which gives maximum gain of 13.2db. The least gain is 9.7db which is obtained at 92.5GHz. The whole graph of gain is obtained in the positive range. Hence it shows that the antenna will work perfectly in the given range.

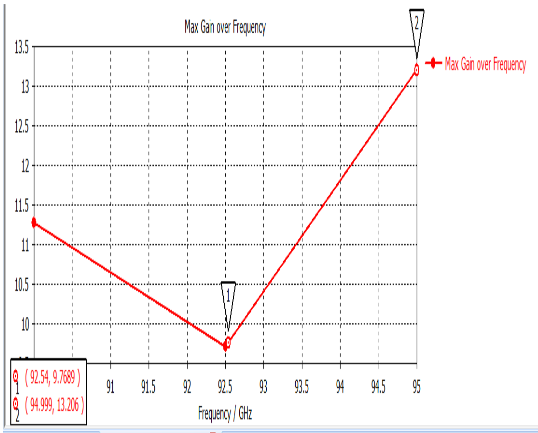

Fig 3: Gain of the proposed antenna

3.3) Radiation Pattern:

The radiation pattern is defined as the graph or plot or a diagram that denotes the directivity of the antenna. It shows that in which direction the energy is spreaded more and in which direction the energy is spreaded less. The radiation pattern sometimes has major lobes and minor lobes. The major lobe shows the direction of maximum power propagated. For a good antenna, the minor lobes and side lobes should be minimized so that it can radiate maximum power in only one dirction. The radiation pattern of the proposed antenna is omnidirectional in the frequency range of 90GHz to 95GHz. The directivity is around 30db at 95GHz and around 20db at 90 and 92.5GHz which is a better one.

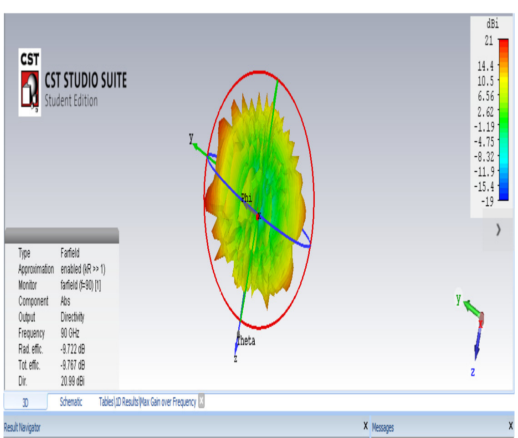

Fig 4: Radiation pattern at 90GHz

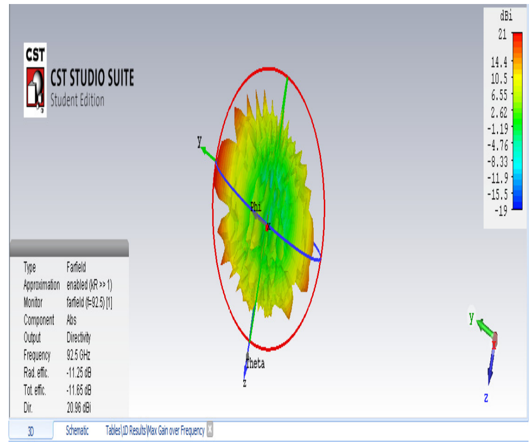

Fig 4: Radiation pattern at 92.5GHz

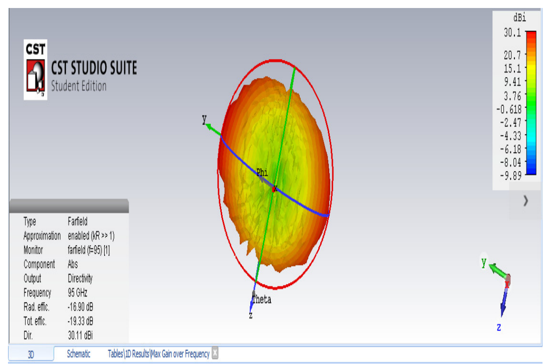

Fig 4: Radiation pattern at 95GHz

4) Conclusion:

In this paper, a conventional millimeter wave patch antenna working in the frequency range of 90 to 95GHz is designed using an FR4 substrate. The antenna operates well in the given frequency range with minimum reflection loss, better gain, radiation pattern and better directivity. In order to enhance the gain and directivity ROGERS RT-5880 substrate is used. It is also noted that in this patch antenna the surface waves are also suppressed to a great extent which is denoted by the value of reflection loss. Better surface wave suppression is obtained at 95GHz. With these advantages, the proposed antenna can become a good candidate for the future 5G millimeter wave cellular wireless networks. The proposed antenna can be used in short range, future high speed and portable communication systems.

REFERRENCES

[1] B. Zhang, Y. P. Zhang, D. Titz, F. Ferrero and C. Luxey, “A circularly-polarized antenna for highly-integrated 60-GHz radio”.
[2] Son Xuat Ta and Ikmo Park, “Broadband Printed Dipole Antennas for Millimeter Wave Applications”.
[3] Kang Ding, Cheng Gao, Dexin Qu and Qin Yin, “Compact Broadband Circularly Polarised Antennas With Parasitic Patches”.
4] Sana Ullah, Sadiq Ullah and Shahbaz Khan, ”Design and Analysis of a 60GHz Millimeter Wave Antenna”.
[5] Y.Suh and K.Chang, “A new millimeter wave printed dipole phased array antenna using microstrip-fed coplanar stripline tee junction”.
[6] R.Alhalabi and G.Rebeiz, “High efficiency angled dipole antennas for millimeter wave phased array applications”.
[7] S.X.Ta and I.Park, “Cavity-backed angled dipole antennas for millimeter wave applications”.
[8] Ashish Kumar, “Rectangular microstrip patch antenna using “L” slot structure”.

4] Sana Ullah, Sadiq Ullah and Shahbaz Khan, ”Design and Analysis of a 60GHz Millimeter Wave Antenna”.
[5] Y.Suh and K.Chang, “A new millimeter wave printed dipole phased array antenna using microstrip-fed coplanar stripline tee junction”.
[6] R.Alhalabi and G.Rebeiz, “High efficiency angled dipole antennas for millimeter wave phased array applications”.
[7] S.X.Ta and I.Park, “Cavity-backed angled dipole antennas for millimeter wave applications”.
[8] Ashish Kumar, “Rectangular microstrip patch antenna using “L” slot structure”.