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A HIGH GAIN AND WIDEBAND NARROW-BEAM ANTENNA FOR 5G MILLIMETER-WAVE APPLICATIONS

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ABSTRACT

A wideband antenna with a high gain and narrow beam-width for future 5G communication systems is presented. The antenna operates in 28 GHz 5G band with a large 35.53% bandwidth ranging from 23.41-33.92 GHz. The array has 4-elements arranged in a linear fashion to attain a high gain.

It radiates along its end-fire direction and provides a very narrow beam-width in its H-plane. A corporate feed network specifically designed for thin substrates was used in order to excite the array elements.

It is built upon thin 0.254 mm Roger's substrate to minimize transmission losses and attain high radiation efficiencies of more than 90% throughout its operating frequency range. It has a compact structure bearing low cost and is easy to fabricate. This antenna fulfils necessary requirements of 5G communication and is therefore a good candidate to be used in the Millimeter -wave range.

Keywords: 5G-communication technology, High Gain, WideBand, Narrow-Beamwidth, Rogers RT5880, Loss Tangent, Substrate, microstrip line feeding.

I. INTRODUCTION

An antenna is an array of conductors (elements), electrically connected to the receiver or transmitter. Antennas can be designed to transmit and receive radio waves in all horizontal directions equally (omnidirectional antennas), or preferentially in a particular direction (directional, or high-gain, or "beam" antennas). An antenna may include components not connected to the transmitter, parabolic reflectors, horns, or parasitic elements, which serve to direct the radio waves into a beam or other desired radiation pattern. Strong directivity and good efficiency when transmitting is hard to achieve with antennas with dimensions that are much smaller than a half wavelength. The first antennas were built in 1888 by German physicist Heinrich Hertz in his pioneering experiments to prove the existence of waves predicted by the electromagnetic theory of James Clerk Maxwell. Hertz placed dipole antennas at the focal point of parabolic reflectors for both transmitting and receiving. Starting in 1895, Guglielmo Marconi began development of antennas practical for long-distance, wireless telegraphy, for which he received a Nobel Prize.

II. ANTENNA SIMULATION

The suggested Antenna has been simulated on MATLAB 2013a

The Width of the patch(W)= $\frac{\lambda}{2}\left(\sqrt{\frac{2}{\varepsilon_r+1}}\right)$………(1)

Effective length(L_{eff})= $\frac{c}{2f\sqrt{\varepsilon_{eff}}}$

Length of the patch(L)= L_{eff}-2ΔL……….(2)

Extension in the length (ΔL)=0.412h $\frac{(\varepsilon|eff+0.3)}{(\varepsilon|eff-o.258)\frac{\left(\frac{W}{h}+0.264\right)}{\left(\frac{W}{h}+0.8\right)}}$

Effective Dielectric length (ε_{eff}) = $\frac{\varepsilon_r+1}{2}+\frac{\varepsilon_r-1}{2}\left[1+12\frac{h}{W}\right]^{-1/2}$

f = Resonance Frequency (its value is 33 GHz)

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h = thickness of substrate (its value is 1.52 mm)

ε_r = relative Permittivity of the dielectric substrate (its value is 2.2)

c = the Speed of light: 3 x 108 m/s

λ = c/f = $3 \times 10^8 / 33 \times 10^9$ = 0.009 m or 9 mm

Calculate above equations (1) and (2)

Obtained Width of the patch W=0.728mm,

Length of the patch L=6.35 mm.

The Width of the feed is same as the width of strip line i.e., W=0.728mm

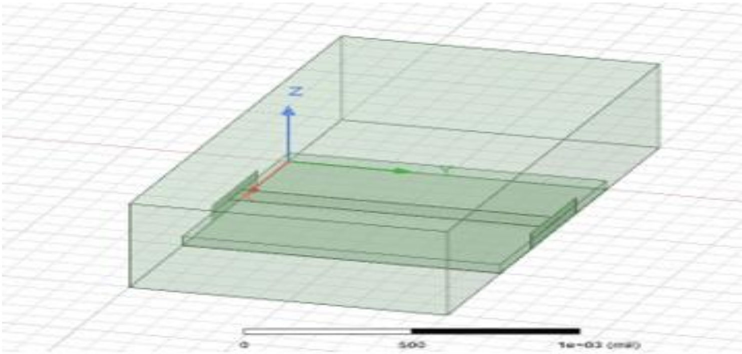
Length of the feed L=6.35mm

In our design we chose substrate Rogers RT5880, it has a dielectric loss of 2.2 with loss tangent 0.0013.

III. ANTENNA DESIGN STEPS

First the antenna designed to resonate at 28GHz. The dimension of the patch, substrate and ground were calculated using TL equations. The copper material used for designing patch and ground layer. The substrate used is Rogers RT5880 material having dielectric constant of 2.2 with loss tangent 0.0013. The Transmission line feed mechanism is used to provide feed to the antenna.

ANTENNA STRUCTURE



3D view of Antenna

Figure 1: Antenna Structure.

IV. RESULTS AND DISCUSSION

The Microstrip Patch Antenna is designed for frequency of 28 GHz which gives results like Response in U space, Array response 2-D polar scope, Blake chart, Simulated radiation efficiency, simulated and Measured gain, Gain vs Frequency, Return loss and VSWR and frequency vs Power frequency, Fabricated antenna.

RESPONSE IN U SPACE:

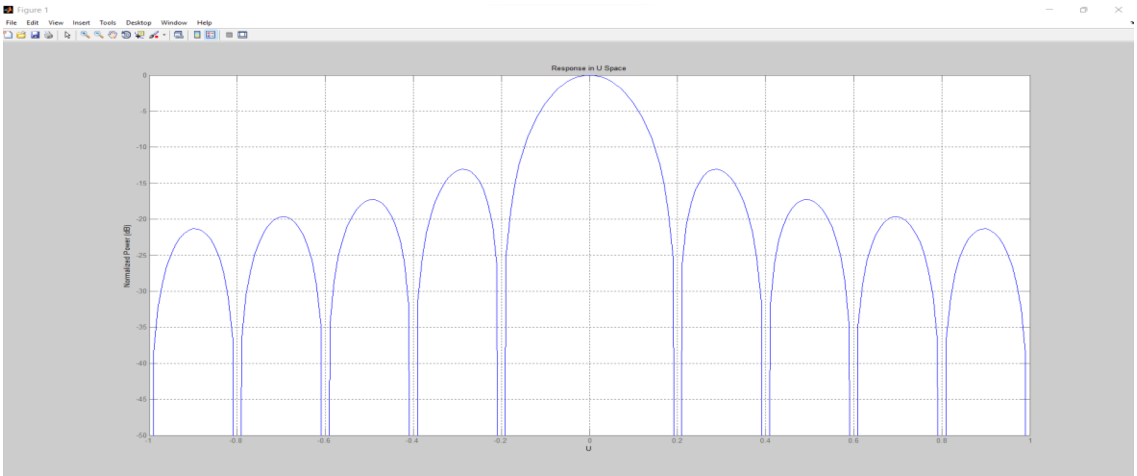


Figure 2: Response In U Space

ARRAY RESPONSE 2-D POLAR SCOPE:

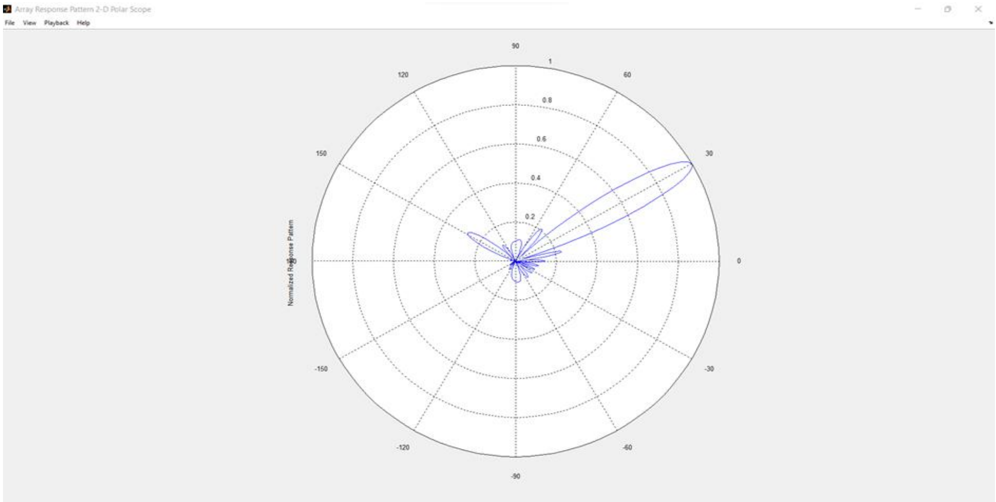


Figure 3: Array Response 2-D Polar Scope

Blake Chart:

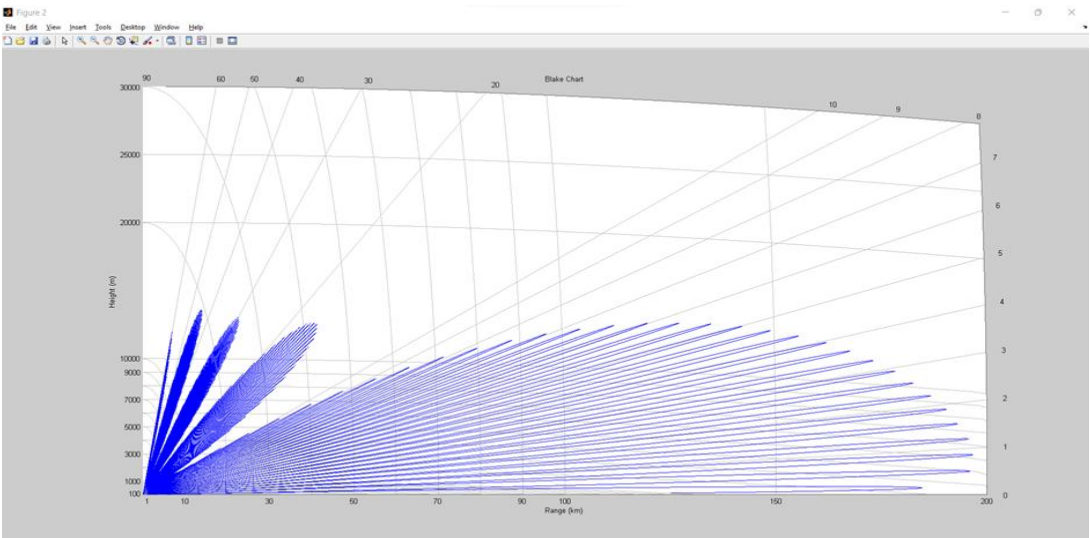


Figure 4: Blake Chart

SIMULATED RADIATION EFFICIENCY,SIMULATED AND MEASURED GAIN:

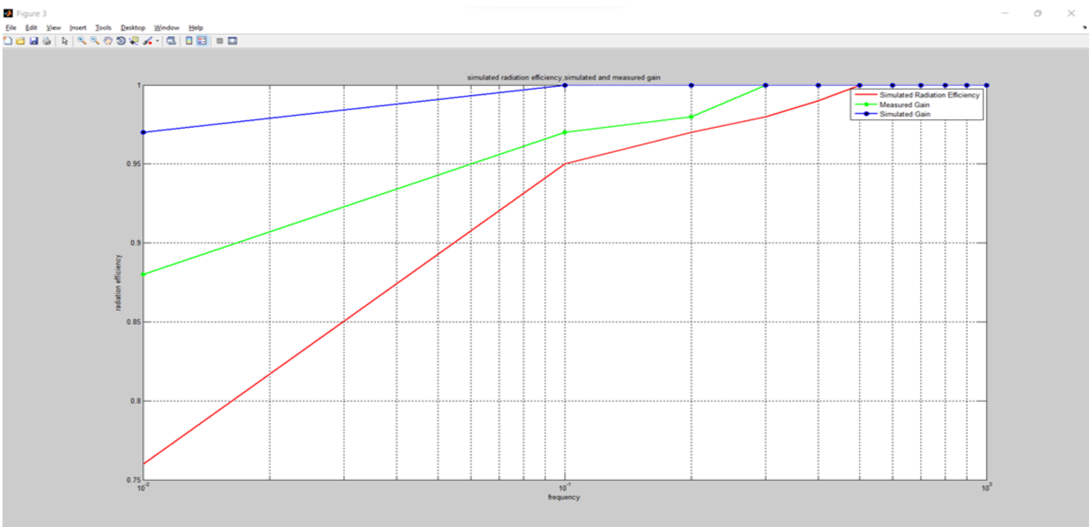


Figure 5: Simulated Radiation Efficiency,Simulated And Measured Gain

GAIN Vs FREQUENCY:

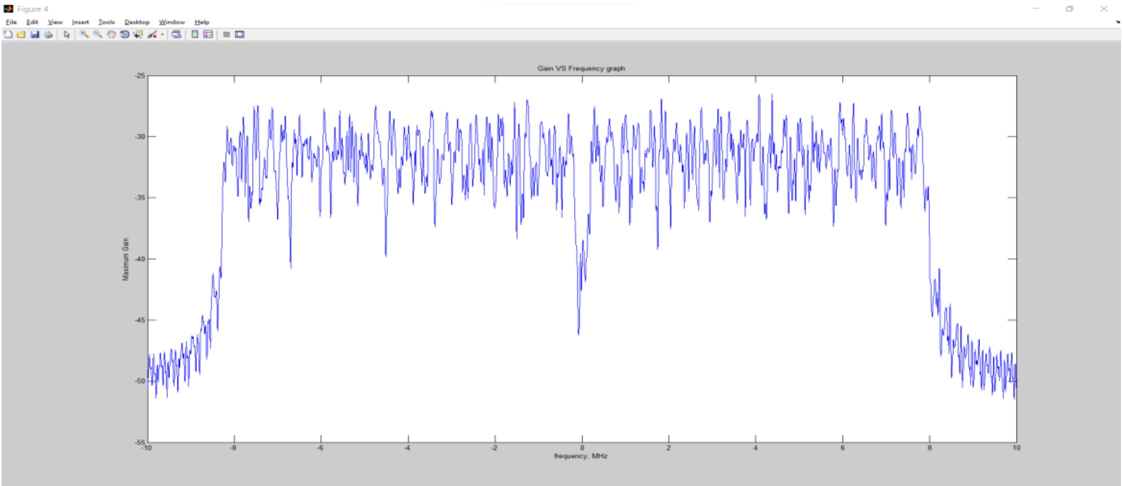


Figure 6: Gain Vs Frequency

RETURN LOSS & VSWR

FREQUENCY VS POWER FREQUENCY

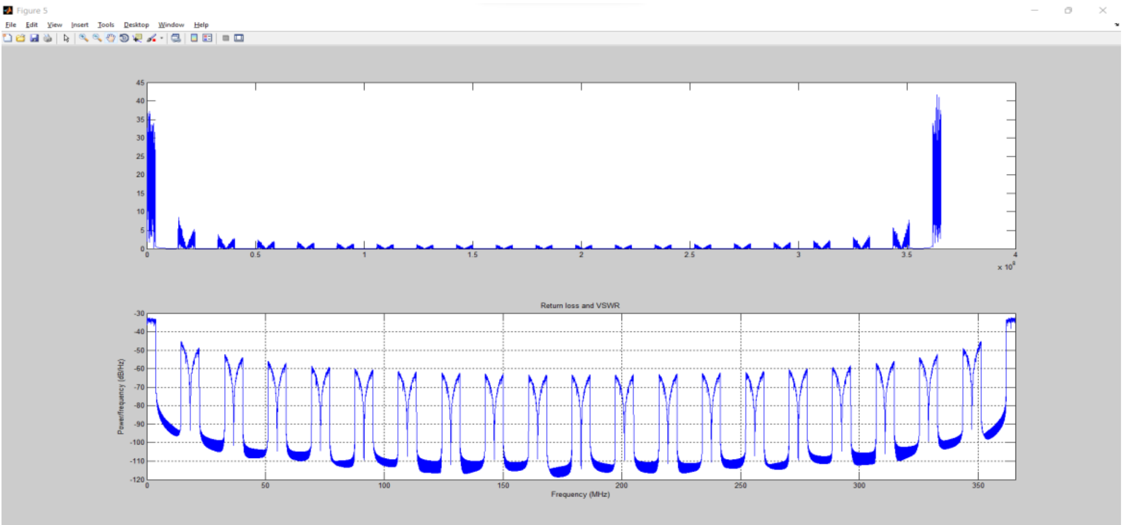


Figure 7: Return Loss & VSWR, Frequency Vs Power Frequency

FABRICATED ANTENNA:

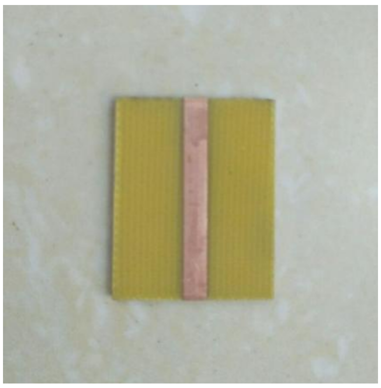


Figure 8: Fabricated Antenna

V. CONCLUSION

The project presented a planar millimetre-wave antenna that provided a high gain of 10.7 dB along with a very wide bandwidth of 10.51 GHz in 23.41-33.92 GHz frequency range.The antenna's characteristics include its end fire radiation pattern which fulfils a key requirement for 5G antennas i.e. narrow beam-width and high gain. Not only that it has ahigh gain, but it also has a wide bandwidth which is another key requirement for Gbps 5G communications. A low transmission loss 4-way feed network has been used to excite each antenna element arranged in linear configuration

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