Design of Rectangular Microstrip Antenna 2 x 2 Array for 5G Communication

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Abstract: ***Microstrip antennas are currently popular because they have the advantage and meet the demand for small and lightweight antennas so that they are compatible and easy to integrate. The aim is to design an antenna microstrip rectangular 2x2 array, a rectangular patch microstrip antenna consisting of four elements. The antenna has a patch size of 17.22 mm x 12.72S mm array 2x2 with a frequency of 5.4 GHz. The antenna design is made in a simulation that works at a frequency of 5.4GHz, and the substrate material is made of Rogers R04350, which has a constant (εrof) of 4.4, while patch materials are made of copper. Calculating the value of the initial antenna parameters will be optimized by sweeping the parameters to obtain the desired return loss, VSWR, gain and bandwidth. The array technique of a microstrip antenna offers advantages, such as low profile, easy to make, easy to feed, easy to be combined with other microstrip circuit elements, easy to integrate into the system, and especially increasing gain. Designing and parameterization are conducted with HFSS***

Keywords: 2*2 array antenna, microsrtrip antenna array, HFSS

1. Introduction

With the increasing number of users, the frequency allocation is decreasing due to limited channel bandwidth. In the same frequency bandwidth, the number of users cannot exceed the specified limit. Also, co-channel interference increases with an increase in the number of users. After the evolution of high definition video (HD) resolution and quadruple high definition (QHD), it became tough for handheld devices to send or receive large volume videos on 3G and 4G frequency channels. Thus, it is necessary to have wider bandwidth and faster data rates for short transmission and wireless reception of high-quality multimedia from one terminal to another. To solve this problem, 5G frequencies are being scrutinized for their wider bandwidth. 5G offers a greater bandwidth with a more significant number of frequency channels compared to 3G and 4G making it suitable for an increasing number of users demanding fast data speeds on the go. In recent times 5G technology is being projected in Indonesia, 5G technology is a new generation in radio systems that have a network architecture that presents broadband connectivity, ultra- robust, extremely low latency to massive network for the community and internet of things. The application of 5G technology is to use frequencies in high-frequency domains but has a small wavelength, or that is covered with Millimeter Wave (mmWave). Millimeter-wave frequency isa high domain frequency name with a carrier frequency range between 3 GHz – 300 GHz, in millimeter-wave technology developed for short-distance service communication but can also be used as a backbone in communication network systems. The best frequency range candidates in Indonesia have frequencies of 700 MHz, 3.5 GHz, 26 GHz, and 28 GHz.

The evolution of mobile communication technology has had a huge impact on the lives of the world's people. In the last decade we have witnessed a revolution in how humans communicate, share ideas and live through wireless communication networks. Both use third generation (3G) and fourth generation (4G) mobile networks. The world is currently preparing with the fifth generation (5G) as a platform that can integrate various wireless communication technologies with various types of services in it as well as the ability to provide connections whenever and wherever we are. Based on Vigilante and Dahmal technology will surpass previous technologies giving birth to a term called networked society, which is a connection that can reach everything around us. In cellular telecommunication systems, antennas are one of the most important components. The use of high frequencies can cause the dimensions of an antenna to shrink, so 5G technology requires an antenna that is easy to integrate.

One type of antenna that is suitable to be a candidate for 5G technology, namely microstrip antennas. Microstrip antennas are thin, small, easy to integrate and can operate at high frequencies. However, microtsrip antennas have a disadvantage, namely narrow bandwidth, so special techniques are needed to be able to increase the bandwidth of microstrip antennas. In addition, microstrip antennas produce a small gain, so the technique of array preparation is needed. Array arrangement can increase the gain and reactivity of an antenna, so that the direction of the antenna beam becomes more directional. This is indispensable in 5G technology.

Furthermore, this paper is classified into several sections. Sections 2 and 3 analyze the proposed array antenna design and comparison of different substrates and feeding techniques, whilst sections 4 and 5 describe the results and conclusion, which are addressed collaboratively and yet are concluded by references.

2. Antenna Design Methodology

Following are the parameters used to design the antenna.
W: The width of patch antenna
L: The length of the patch antenna
λ_0: The Wavelength
f_0 : The operating frequency
ε_r: dielectric constant

ΔL: Length extension
ε_{reff}: Dielectric constant effective

Height of the substrate
W_g : Width of ground
L_g: Length of ground
C: Velocity of light

The following stages are involved in designing amicrostrip patch antenna:

Calculation of Width (*w*):

$$W = \frac{C}{sf0\sqrt{\frac{\varepsilon r+1}{2}}} = \frac{3\ X10^8}{2\ X\ 5.4\ X10^9\sqrt{\frac{4.4+1}{2}}}$$

W= 17.22mm

Calculation of Effective dielectric constant (εreff):

$$\varepsilon reff = \frac{\varepsilon r+1}{2} + \frac{\varepsilon r-1}{2}\left(\frac{1}{\sqrt{1+12(\frac{h}{w})}}\right)$$

$$\varepsilon reff = \frac{4.4+1}{2} + \frac{4.4-1}{2}\left(\frac{1}{\sqrt{1+12(\frac{2}{17.22})}}\right)$$

$$\varepsilon reff = 3.8mm$$

Calculation of effective length (*Leff*):

$$L\triangle = (0.412)(h)\left[\frac{\left(\frac{w}{h}+0.264\right)(\varepsilon reff+0.3)}{(erff-0.264)(\frac{w}{h}+0.813)}\right]$$

$$L\triangle = (0.412)(h)\left[\frac{\left(\frac{17.22}{2}+0.264\right)(\varepsilon reff+0.3)}{(erff-0.264)(\frac{17.22}{h}+0.813)}\right]$$

$$L\triangle = 3.0532mm$$

Calculation of the length of the patch (*L*):

$$L = Leff - 2\nabla L$$

$$L = 12.72mm$$

Calculation of Dimensions of ground plane:

$lg = 6h + l$= 6x2+12.72
lg= 24.72mm
$wg = 6h + w$= 6x2+17.22
wg=29.22mm

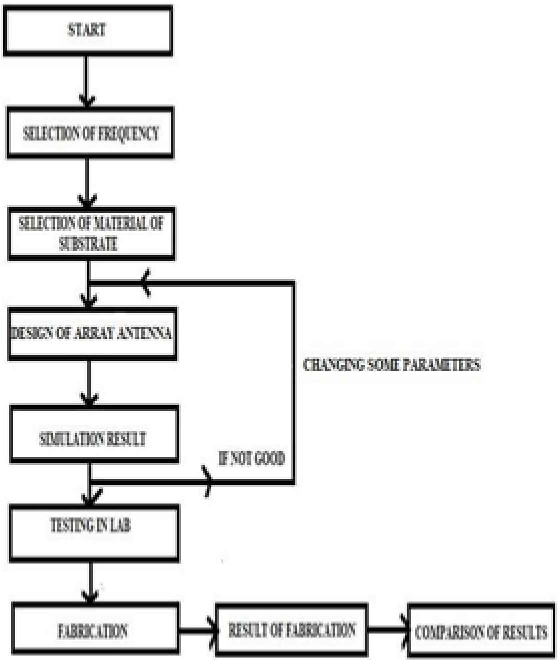

Figure 1: Algorithm of process

The methodology adopted in designing, simulation, fabrication and measurement of the antennas proposed in this thesis is presented in this section. Antenna design, simulation and parametric analyses for the antennas is carried out using Ansoft HFSS simulation software. Antennas are fabricated utilizing the Photolithographic process on an easily available FR-4 substrate. The developed prototypes of the antennas can be tested using Vector Network Analyzer (VNA) in the anechoic chamber.

3. Results and Discussion

As the design process goes the calculation of the parameters are done above and with the dimensions the 2*2 array rectangular patch antenna has been designed by Microstrip Line Feed Technique. The table 1 below gives the possible parameters for the design of the 2*2 array Microstrip patch antenna which will be used in the software for the results to examine.

Table 1: Parameters used in the software for the responses andsimulations

Parameters	Values
Dielectric Constant of theSubstrate	4.4
Centre Frequency	5.4GHz
Width of the patch	17.22mm
Length of the Patch	12.72mm
Dimensions ofground plane: lg= Wg=	 23.5mm 24mm
Dielectric height	2mm

Construction of 2*2 array rectangular antenna:

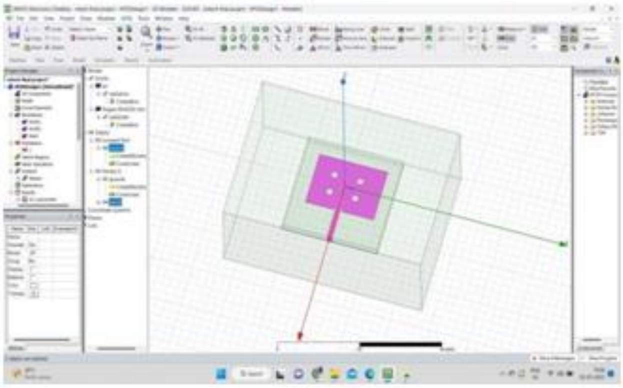

Figure 2: Basic 2*2 array Rectangular patchmicrostrip antenna in HFSS

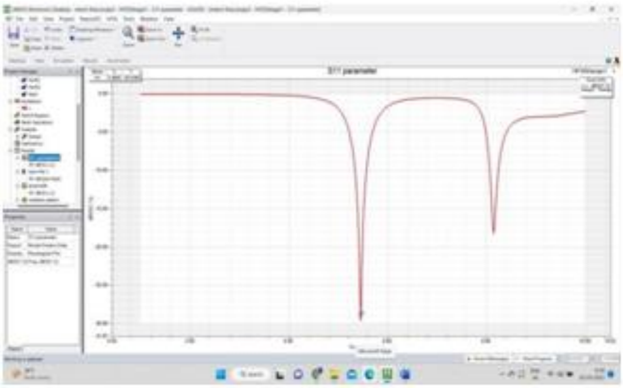

Figure 3: Graph of Resonant Frequency and Bandwidth

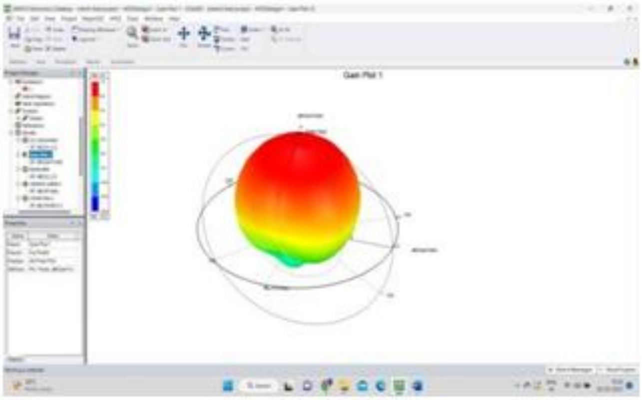

Figure 4: Gain Graph

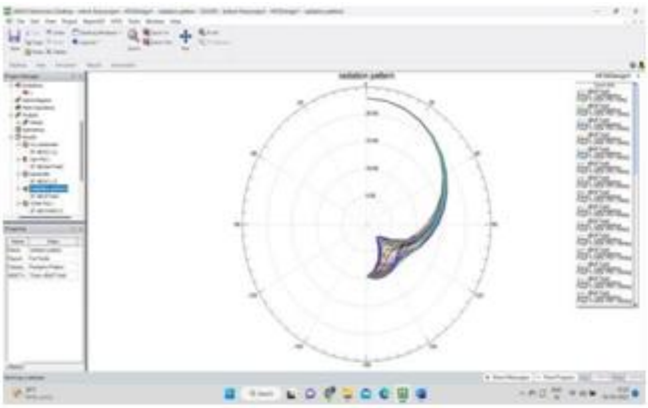

Figure 5: Radiation pattern

Table 2: Result values

Resonant Frequency	5.4GHz
Bandwidth	520MHz
Gain	6.019
Patch Width	12.72mm
Patch Length	17.22mm

1) Comparison of different substrate materials

This study compares four substrate materials—Rogers R04350, FR4, Arion AD430 and Bakelite—that are needed to create a microstrip patch antenna that operates in the 6.7 GHz frequency range. This paper compares several substrates and suggests one that can be utilized in a patch antenna in a specific frequency range.

Table 3: Result values

Substrate	Rogers R04350	FR4	Arion AD430	Bakelite
Resonant Frequency	5.46GHz	5GHz	5GhZ	4.8GHz
Bandwidth	520MHz	880MHZ	580MHz	640MHZ
Gain	6.019DB	4.43DB	5.8DB	5.4DB

2) Comparision of different feeding techniques

This study compares four substrate materials—Rogers R04350, FR4, Arion AD430 and Bakelite—that are needed to create a microstrip patch antenna that operates in the 6.7 GHzfrequency range. This paper compares several substrates and suggests one that can be utilized in a patch antenna in a specific frequency range.

Table 4: Result values

Feed	Microstrip Line	Coaxial	Aperture	Edge feed
Resonant Frequency	5.46GHz	5.5GHz	6.7GHZ	5.3GHz
Bandwidth	520MHz	1GHZ	1.54GHz	700MHZ
Gain	6.019DB	2.26DB	5.0DB	5.1DB

4. Conclusion

The proposed design of a 2*2 array microstrip patch array antenna for 5g communication having 12.72*17.22 mm2 dimensions. For the proposed design the feeding line gives good control, gain and bandwidth and a very good return loss results. This proposed micro strip patch array antenna 2x2 operates at 6.7GHz has a bandwidth equal to 1.54GHZ, a gain equal to 5 dB. There are the four feeding techniques and Substrate for the 2*2 Array Rectangular MPA is compiled and compared in terms of return loss, Gain, and Bandwidth. The following conclusions are made from the comparative study of the different feeding techniques and substrates of thepatch antenna:

1) The proper selection of a feeding technique and Substrate for a microstrip patch antenna is important because it affects the bandwidth, S11, VSWR, patch size, radiation efficiency, and impedance matching.
2) Microstrip Line fed antenna has the highest gain and lowest moderate frequency. Edge feed has moderate frequency, bandwidth and gain. Aperture coupled fed antenna have high frequency, high bandwidth and moderate gain, so it is used
3) FR4 has the highest bandwidth and lowest gain. Arion has moderate frequency, bandwidth and gain. Bakelite

has the lowest frequency and moderate bandwidth and gain. Rogers substrate have high frequency, moderate bandwidth and high gain, so Rogers is used

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