Design of Rectangular Microstrip M-array Patch Antenna for Ku – band

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Abastruct –- This paper presents the design and simulation of a two-Patch antenna utilizing the CST simulation tool. The antenna is tailored for Ku-band applications. The design incorporates an RT5880 substrate characterized by a dielectric constant of 2.2, and a microstrip line serves as the antenna's feed line. The antenna exhibits key performance metrics: a return loss with a bandwidth, a gain, and a directivit.

Keyword Microstrip , VSWR, Return loss, Gain, DGS

i. Background

Microstrip Patch Antenna is widely used in wireless communication systems, thanks to its many advantages, it is inexpensive, light weight and small size, which makes it easy to integrate into electronic devices.It is used to transmit signals, wireless signals between phones and wireless towers, as well as in satellite systems, in terms of sending and receiving signals between the earth station and satellites. In this paper, the focus has been on designing a microstrip patch antenna in a frequency range ku_Band.

ii. Review of Previous Works

It is designed for 3.5 GHz frequency which is used for the applications of S-band. The antenna is structured using an FR4 substrate, which dielectric constant is 4.4 and a microstrip line is used as a feeding technique for the designed antenna. The performance of the antenna at 3.5 GHz produced a better return loss value of-43.52 dB, a large bandwidth of 2.3 GHz between 2.6 GHz and 4.9 GHz, and a gain of 2.646 dBi. To boost bandwidth, the substrate's thickness is raised. [1] This study aims to design an antenna microstrip rectangular 1x2 array, a rectangular patch microstrip antenna consisting of two elements. The antenna has a patch size of 19.5 mm x 26.5 mm array 1x2 with a frequency of 3.5 GHz. The antenna design is made in a simulation that works at a frequency of 3.5 GHz, and the substrate material is made of FR 4, which has a constant (ε r of) of 4.3, 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, bandwidth, and directivity. The results of optimization of the rectangular microstrip antenna design 1x2 array work at a frequency of 3.5 GHz with a return loss -12.54 dB in the frequency range 3. 47 GHz up to 3.53 GHz, bandwidth 66.5 MHz, VSWR value of 1.6 and produce a gain of 5.5 dB. [2].

iii. ANTENNA DESIGN

The microstrip patch antenna consists of four key elements: the ground, the substrate, the patch, and the feed. The substrate has a dielectric constant, while the ground serves as a rectangle-shaped ground plane. When designing the antenna using the CST program, various metrics can be displayed, including return loss, VSWR, directivity, gain, and bandwidth.

a. Design of Microstrip Patch Antenna

Designed for the Ku-band, as shown in Figure 1, this design is centered on achieving specific performance criteria within the frequency range, including return loss, VSWR, high gain, and directivity. Antenna dimensions are measured by the following formulas, in the following table.1 the parameters used are shown.

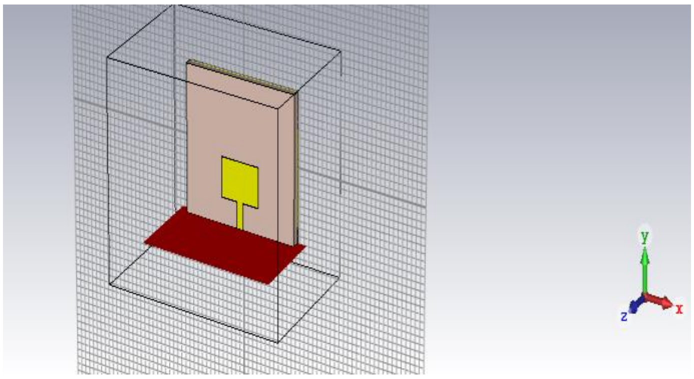

Fig.1 Design of Rectangular Microstrip M-array Patch Antenna

Table.1 The parameters

Parameter	Dimension
Width the ground : wg	25
Width the Substrate : wg	25
Length the ground : lg	20
Length the ground : lg	20
Thickness the patch : h	1.58
Thickness the Substrate : h	1.58
Thickness the feed line : h	1.58
Width the feed line : wf	1.5
Length the feed line : lf	3.59
Thickness the ground : t	0.035
Width the patch : wp	8.547
Length the patch : lp	5.418

b- Design of Micro-strip two Patch Antenna

The design of a microstrip two-patch antenna involves creating a specialized antenna system with two patch elements for the Ku-band, as illustrated in Figure 2, this design focuses on attaining specific performance criteria within the frequency range, encompassing parameters such as return loss, VSWR, high gain, and directivity. Antenna dimensions are measured by the following formulas, in the following table.2 the parameters used are shown**.**

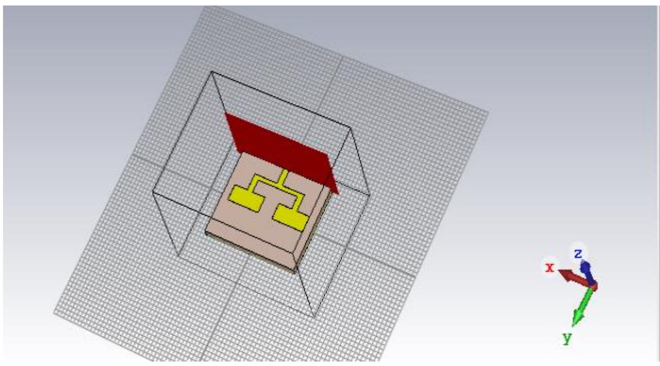

Fig.2 Design of Rectangular Microstrip M-array Patch Antenna

Table.2 The parameters

Parameter	Dimension
Width the ground : wg	25

Width the Substrate : wg	25
Length the ground : lg	20
Length the ground : lg	20
Thickness the patch : h	1.58
Thickness the Substrate : h	1.58
Thickness the feed line : h	1.58
Length the patch1 : lf	5.418
Length the patch2 : lf	5.418
Width the patch1 : wp	8.547
Width the patch2 : wp	8.547
Thickness the ground : t	0.035

c- Design of Micro-strip two Patch Antenna With Defected ground structure (DGS)

In the design of a Ku-band microstrip two-patch antenna with a Defected Ground Structure (DGS) in Figure 3, a specialized antenna system is created by incorporating DGS elements into the ground plane. This design is meticulously crafted to achieve precise performance criteria within the Ku-band frequency range, including optimizing parameters such as return loss, VSWR, high gain, and directivity. . Antenna dimensions are measured by the following formulas, in the following table.3 the parameters used are shown

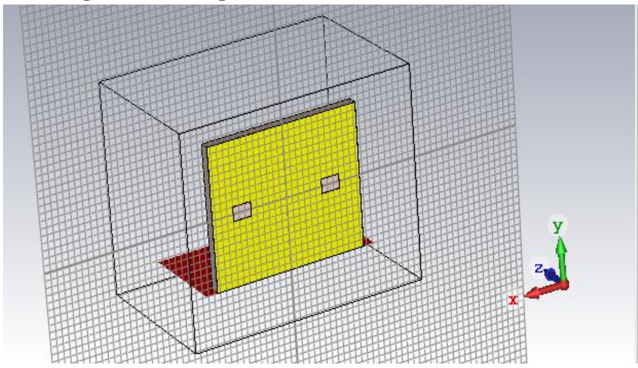

Fig.3 Micro-strip two Patch Antenna With Defected ground structure (DGS)

Table.3 The parameters

Parameter	Dimension
Width the ground : wg	25
Width the Substrate : wg	25
Length the ground : lg	20
Length the ground : lg	20
Thickness the patch : h	1.58
Thickness the Substrate : h	1.58
Thickness the feed line : h	1.58
Length the patch1 : lf	5.418
Length the patch2 : lf	5.418
Width the patch1 : wp	8.547
Width the patch2 : wp	8.547
Thickness the ground : t	0.035
m1	3.5
m2	6.5
b	2

iv. SIMULATION RESULT ANALYSIS

a. Simulation and Analysis of Micro-strip Patch Antenna

When designing a patch antenna for the 15.25 GHz band, as shown in Figure 4, it's important to consider the S11 value, which represents the reflection coefficient and indicates the amount of energy reflected by the antenna. An S11 value of -34.843 dB or lower at the operating frequency of 15.25 GHz, along with a bandwidth of 1.124 GHz (with a high frequency(Fh) of 15.842 GHz and a low frequency(Fl) of 14.718 GHz) , for calculating the BandWidth using the equation.1.

$$BW = Fh - Fl \quad (1)$$

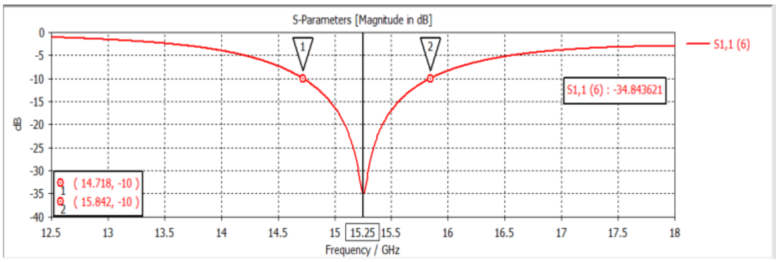

Fig. 4. S-Parameters of the designed Patch Antenna

In the design of a Microstrip Patch Antenna, the Voltage Standing Wave Ratio (VSWR), which measures the power reflected by the antenna, is a critical parameter. In this particular simulation, the results reveal a VSWR value of 1.036, as shown in Figure 5.

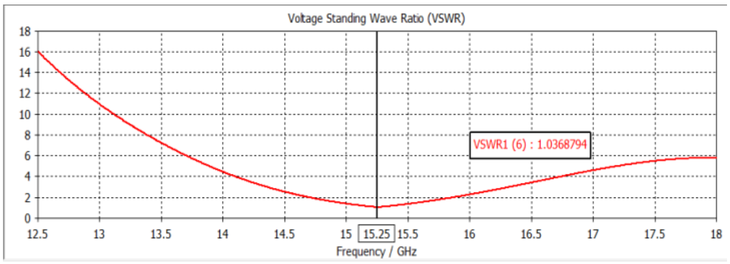

Fig. 5. VSWR of the designed Patch Antenna

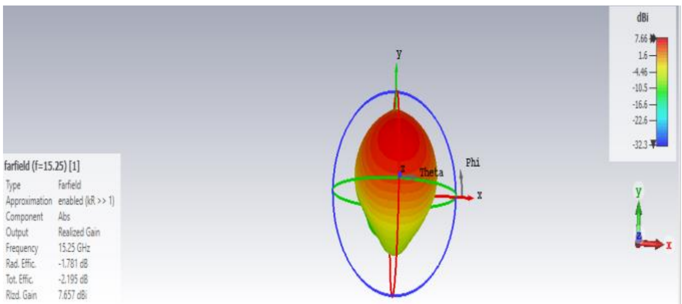

Fig. 6. Gain of the designed Patch Antenna

At a frequency of 15.25 GHz, the antenna exhibited a gain of 7.66 dBi and directivity of 9.852 dBi, as shown in Figure 6 and Figure 7.

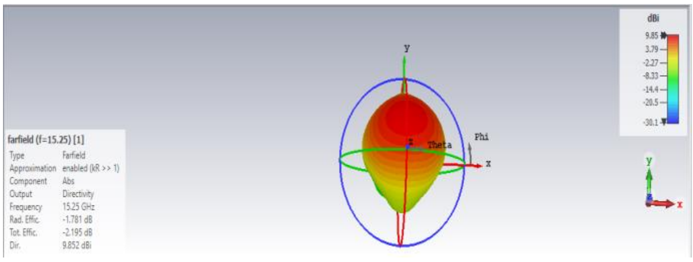

Fig. 7. Directivity of the designed Patch Antenna.

b. Simulation and Analysis of Micro-strip two Patch Antenna

When designing a dual Patch Antenna for the 15.255 GHz band, as shown Figure 8, it is crucial to consider the S11 value. S11 represents the reflection coefficient, indicating the amount of energy reflected by the antenna. An S11 value equal to or below -19.178352 dB at the operational frequency of 15.255 GHz, combined with a bandwidth of 0.937 GHz with a high frequency (Fh) of 15.751 GHz and a low frequency (Fl) of 14.814 GHz.

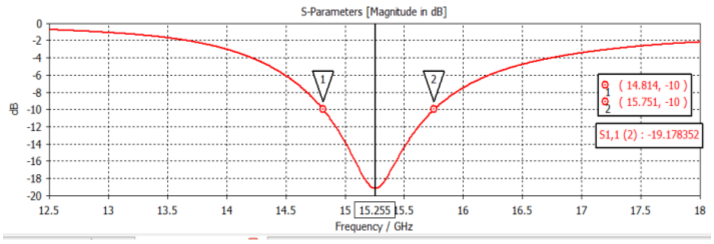

Fig. 8. S-Parameters of the designed dual Patch Antenna

When designing a Micro-strip dual Patch Antenna, it is crucial to consider the Voltage Standing Wave Ratio (VSWR), a critical parameter that quantifies the power reflected by the antenna. In the specific simulation conducted, the VSWR value was determined to be 1.2469, as shown in Figure 9.

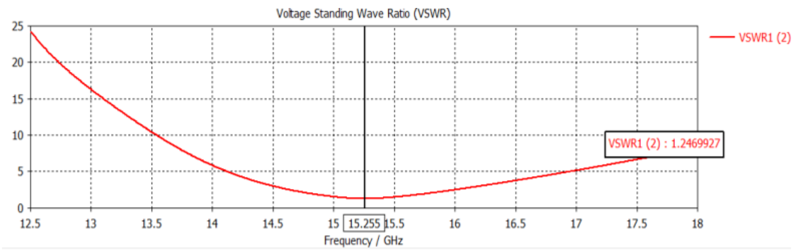

Fig. 9. VSWR of the designed dual Patch Antenna

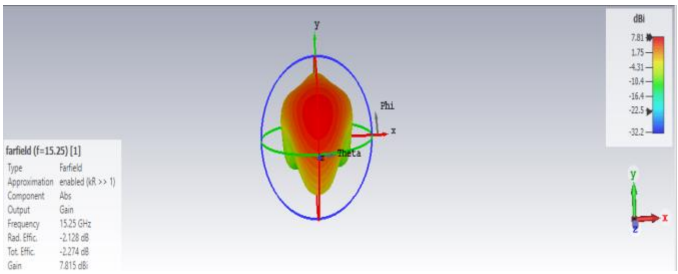

Fig. 10. Gain of the designed dual Patch Antenna

The antenna operating at 15.255 GHz, demonstrated a gain 7.81dBi and a directivity of 9.943dBi, as shown in Figure 10 and Figure11.

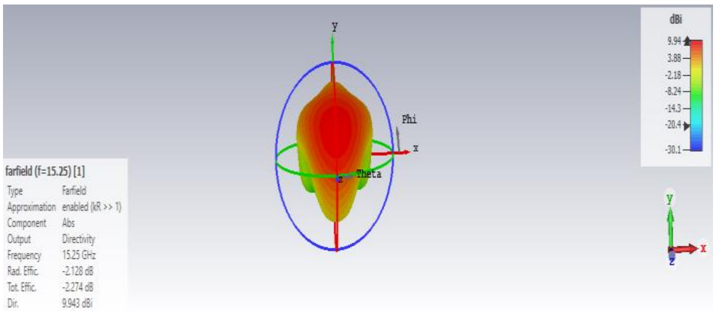

Fig. 11. Directivity of the designed dual Patch Antenna.

c. **Simulation and Analysis of Micro-strip two Patch Antenna With Defected ground structure**

In the process of designing a Micro-strip two Patch Antenna With ground structurefor the 15.25 GHz band, as shown in Figure 12, it becomes crucial to take into account the S11 value, a representation of the reflection coefficient signifying the energy reflected by the antenna. An S11 value equal to or below -17.310133 dB at the operational frequency of 15.107 GHz, in conjunction with a bandwidth of 0.935 GHz with a high frequency (Fh) of 15.605 GHz and a low frequency (Fl) of 14.67 GHz.

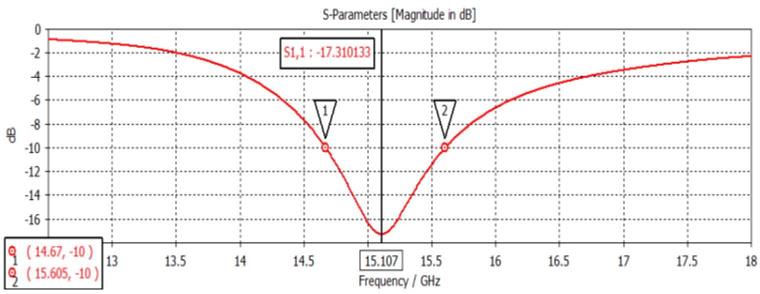

Fig. 12. S-Parameters of the designed Micro-strip two Patch Antenna With Detectve ground structurefor

In the design of Micro-strip two Patch Antenna With ground structurefor, the Voltage Standing Wave Ratio (VSWR) is a critical parameter, quantifying the power reflected by the antenna. In the specific simulation performed, the VSWR value was found to be 1.3156. as shown in Figure 13.

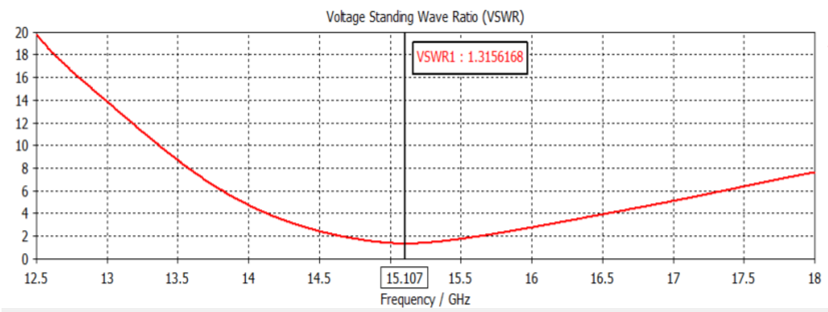

Fig. 13. VSWR of the designed Micro-strip two Patch Antenna With Detectve ground structurefor

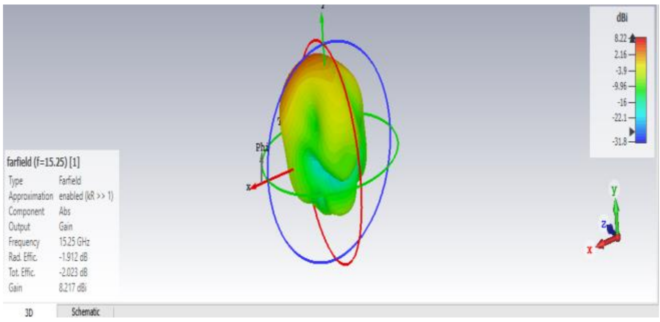

Fig. 14. Gain of the designed Micro-strip two Patch Antenna With Detectve ground structurefor

At a frequency of 15.107 GHz, the antenna showcased a gain of 8.22 dBi and a directivity of 10.1 dBi, as shown in Figure Figure 14 and Figure 15.

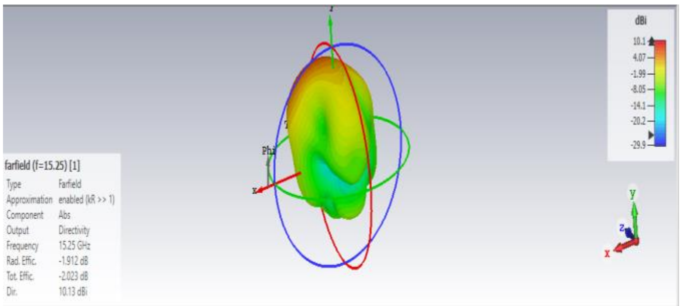

Fig. 15. Directivity of the designed Micro-strip two Patch Antenna With Detectve ground structurefor

Table.4 The Bandwidth is high

bandwidth (B.W) GHz	Gain [dBi]
0.738	**5.92**
0.759	**6.04**
0.761	**6.21**
0.759	**6.37**
0.753	**6.53**
0.764	**6.79**
0.752	**6.65**

Table.5 The Gain is high

bandwidth (B.W) GHz	Gain [dBi]
0.504	**6.96**
0.734	**7.11**
0.728	**7.26**
0.723	**7.41**
0.714	**7.56**

i. CONCLUSION

Incorporating Defected Ground Structure (DGS) into a Microstrip Two Patch Antenna design has shown significant improvements in both gain and directivity. Following the outlined design process ensures the creation of a well-optimized antenna with desirable performance characteristics, including gain. Utilizing a microstrip line as the feed line efficiently transfers signals from the transmission line to the antenna element. Careful selection of substrate material, patch dimensions, and feed location is pivotal in achieving the necessary performance parameters.

REFERENCES

[1] (PDF) Design and Analysis of 3.5 GHz Rectangular Patch Microstrip Antenna for S-Band Applications (researchgate.net)

[2] (PDF) Design of Rectangular Microstrip Antenna 1x2 Array for 5G Communication (researchgate.net)