Design of Trophy Shaped Microstrip Antenna for C- band application

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***Abstract*—In this research paper, the design and analysis of microstrip patch antenna are elaborated. In this case, the geometry of the antenna was changed using trophy shape for compatibility with C-band communication. More precisely, the designed microstrip patch antenna has a resonant frequency of 7.71 GHz for use in satellite communication systems and wireless data transmission. This antenna is fabricated on an FR-4 substrate with a dielectric constant of 4.4 and height of 1.6 mm. Consequently, the produced antenna becomes very economical to fabricate. As can be noted, the outstanding property of the antenna is the change in shape of the patch. From the illustration provided, it can be seen that the patch has a trophy shape, thus improving the current path without changing the size of the antenna. Microstrip line was employed as the antenna feed to maintain a characteristic impedance of 50 Ω. The design and analysis of the antenna are carried out using ANSYS HFSS software with finite element method technique. From the simulation results, the return loss and VSWR were found to be -24.81 dB and 1.12, respectively. These figures show good impedance matching**

***Index Terms*—Microstrip antenna, C-band, HFSS, impedance matching, patch antenna, satellite communication**

I. INTRODUCTION

Antennas are really important for communication systems because they help devices send and receive signals. In things like satellite communication and wireless networks people want antennas that're small and work well. One kind of antenna that people like is the microstrip patch antenna. This is because it is thin and light and can be made using the techniques as printed circuit boards. These antennas have some problems. They can only. Receive signals over a small range of frequencies and they do not work very well at higher frequencies. This means they are not very good for things that need to work at frequencies like the C-band. To fix these problems researchers have tried changing the shape of the antenna and how it's fed signals. In this project we made a microstrip antenna with a special shape that looks like a trophy. We wanted to make the electricity flow better in the antenna without making it bigger. We did this by changing the shape of the part that sends and receives signals. This helps the antenna work at the frequency we want which's 7.71 GHz. This frequency is used for satellite communication. Sending data over long distances. We made the antenna using a material and fed it signals using a microstrip line. We used computer tools to see how well the antenna worked and looked at things like how much signal was sent and how strong the signal was. The results showed that our new antenna works better than the kind, which makes it good for real world wireless communication applications. The microstrip patch antennas are useful for communication systems and the new design of the microstrip antenna with a trophy-shaped radiating patch is an improvement. The microstrip patch antennas have some limitations. The modified microstrip antenna can help to solve these problems. The modified microstrip antenna is designed to work at a frequency, which is 7.71 GHz and it is good for satellite communication and long-distance data transmission. The microstrip patch antennas and the modified microstrip antenna are important, for communication systems.

II. LITERATURE SURVEY

Microstrip patch antennas are really useful for satellite communication systems. [1] Pozar wrote a report about microstrip antennas talking about the good things like they are low profile and easy to make but also the not so good things like they have narrow

bandwidth. [2] Balanis made some models that explain how antennas work and how they behave which is really helpful when designing antennas. Some people tried to make antennas work better by changing their shape. [3] Anguera and his team looked at antennas with shapes and found out that making the path longer helps them work with multiple bands. Kumar and Harish[4] did something they cut slots into the antenna and it made the gain better and changed the frequency without making the antenna bigger. The material used for the antenna is also very important. Tran [5] and his team studied how different materials affect the antenna and they found out that materials with permittivity make the antenna work better and have more gain but materials with higher permittivity make the antenna smaller. Matin and Sharif [6] made an antenna that can work with two bands they changed the shape of the antenna. It worked really well for wireless things. People are also looking at ways to make antennas, like MIMO systems. Naidu [7] and his team made an antenna system with ports and it worked really well it is good, for sending a lot of data. From all the research that has been done it is clear that changing the shape of the antenna and using the material can make it work better. This is why we want to try making a trophy-shaped antenna we think it can work well.
performance

III. ANTENNA DESIGN METHODOLOGY

The proposed antenna is a small microstrip patch structure. It works at 7.71 GHz in the C-band spectrum. The antenna is made on an FR-4 substrate with a permittivity of 4.4 and a thickness of 1.6 mm. Copper is used for the radiating patch and ground plane because it conducts well and is suitable for printed circuit fabrication. A full ground plane is on the surface of the substrate. This helps with radiation and reduces back radiation losses. To design the antenna we calculate dimensions using standard microstrip antenna theory. The patchs width and length are estimated based on the operating frequency and substrate parameters. We consider the effective constant and fringing fields to determine the resonant length. These values give us a baseline design. We then refine it through simulation to achieve resonance and improved impedance matching. A microstrip line feed excites the antenna. The feed line is designed to have an impedance of 50 Ω. This is standard for RF systems. We design the feed line width and its connection to the patch carefully. This ensures power transfer and minimizes reflections. We optimize the feed position to achieve the impedance matching condition. The proposed design has a trophy-shaped radiating geometry. This is different from rectangular patch antennas. The structure has an upper section, a narrow middle region and a wider base connected to the feed line. The goal is to increase the electrical path of surface currents without increasing the antennas size. The curved top section improves radiation by enhancing field distribution. The narrow middle section acts as an impedance transformer. It allows transition of current from the feed line to the radiating area. This results in return loss and improved antenna efficiency. Simulated using ANSYS HFSS. It uses the element method for electromagnetic analysis. During simulation we evaluate performance parameters like return loss, Voltage Standing Wave Ratio and gain. We perform iterations by adjusting geometrical parameters. This helps achieve performance at the desired frequency.

This design methodology ensures the antenna achieves resonance, efficient radiation and good impedance matching. It maintains an practical structure. The antenna is suitable, for satellite and wireless communication applications.

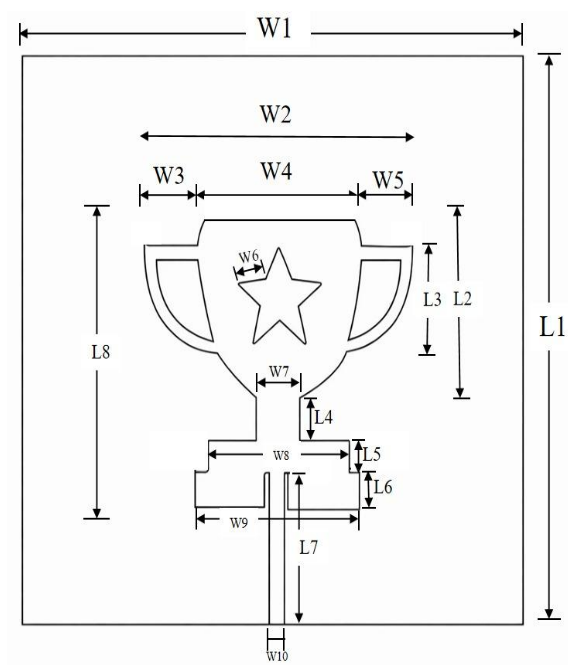

Fig. 1. Microstrip antenna geometry

TABLE I: ANTENNA PARAMETERS

W (Width)	L (Length)
W1 = 60	L1 = 60
W2 = 30.66	L2 = 19.59
W3 = 6.35	L3 = 11.68
W4 = 17.84	L4 = 4.34
W5 = 6.47	L5 = 2.91
W6 = 3.92	L6 = 3.83
W7 = 5.82	L7 = 16
W8 = 17.76	L8 = 30.67
W9 = 20.63	-
W10 = 2	-

The design of the antenna starts with some calculations. These calculations are based on the frequency it will operate at and the properties of the material it will be made on. We calculate the width of the patch how the material affects the signal and the length of the patch. We have to consider the effects of the patch edges on the signal. The final size of the antenna and its parts are shown in Table 1.

This includes the size of the material the width of the feed line and the patch shape. To make the antenna work well we use a microstrip line to feed it. This feed line is designed to have a resistance of 50 ohms. That way power can be transferred efficiently. The feed line is connected directly to the patch. We adjust its position during simulation to make sure it reflects as signal, as possible. This helps the antenna and the feed line work together. The goal is to get the impedance matching right

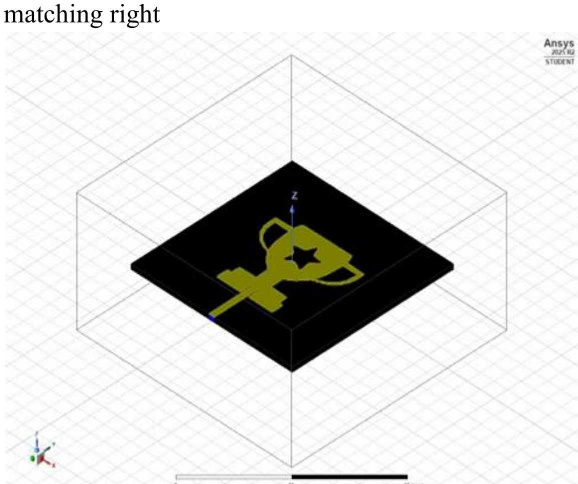

Fig 2 Microstrip antenna in HFSS

The antenna is. Tested using ANSYS HFSS, a tool that is widely used to simulate electromagnetic things. This tool works by breaking down things into smaller parts and solving equations. In ANSYS HFSS a 3D model of the antenna is made by setting up the substrate the part that sends out signals and the ground plane with the properties like how well they carry electricity. The substrate is given its special properties and copper is used for the parts that conduct electricity.

To make the test more real the antenna is put in a space that lets electromagnetic waves move around freely. The antenna is excited using a connection that helps get energy into the system. The way the antenna is fed is designed to keep the impedance at 50 Ω, which's important for sending signals efficiently.

A test is done to see how the antenna works at frequencies, around 7.71 GHz. The antenna is checked for things like return loss, Voltage Standing Wave Ratio and gain to see how well it works. The results show how well the antenna is matched how efficient it is and how well it works overall.

The design of the antenna is. Tested again to get the best results. The shape and size of the parts are adjusted until the antenna works the way it should. This process is repeated until the antenna sends out signals efficiently has losses and works stably which is good for C-band communication. The antenna is designed to work for C-band communication by adjusting the antenna until it has the right properties. The goal is to make the antenna work efficiently and send out signals with losses, which is important for C-band communication applications, like the antenna.

IV. RESULTS AND DISCUSSION

The performance of the proposed trophy-shaped microstrip antenna was looked at using simulation. This was done to see if the antenna is good for C-band communication applications at 7.71 GHz. The results of the simulation show that the antenna works well and is efficient when it comes to impedance matching and how The antenna is. Tested using ANSYS HFSS, a tool that is widely used to simulate electromagnetic things. This tool works by breaking down things into smaller parts and solving equations. In ANSYS HFSS a 3D model of the antenna is made by setting up the substrate the part that sends out signals and the ground plane with the properties like how well they carry electricity. The substrate is given its special properties and copper is

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A test is done to see how the antenna works at frequencies, around 7.71 GHz. The antenna is checked for things like return loss, Voltage Standing Wave Ratio and gain to see how well it works. The results show how well the antenna is matched how efficient it is and how it sends out signals. The special shape of the antenna is important for making it work better than patch structures.

The results show that the antenna works well at the desired frequency with very little signal being sent back and most of the power being transferred. Things like return loss and Voltage Standing Wave Ratio and gain were looked at closely to see how well the antenna works overall. The antenna has reflection and its impedance matching is very good and it sends out signals consistently. It is also small and simple which makes it good for world use.

The results also show that the trophy-shaped design is good at controlling how moves on the surface. By making the shape right the antenna can work well even when a lossy material like FR-4 is used. Overall the simulation shows that the proposed trophy-shaped microstrip antenna is good, for satellite communication applications that need to be reliable. The trophy-shaped microstrip antenna works well for these kinds of applications because of its trophy-shaped design and its ability to send and receive signals efficiently.

The S-parameter, S11 is very important for evaluating how well an antenna works. It shows how much power is sent back from the antenna because of a mismatch. A lower S11 value means the antenna is working better and using power efficiently. In antenna systems an S11 value below −10 dB is good enough. This is because it means that least 90% of the power is used. For our antenna the S11 curve shows a peak at 7.71 GHz. At this frequency the power sent back is very low about dB. This low value means that most of the power is radiated into space not sent. The shape of our antenna helps it work better. It makes the flow smoothly and reduces problems with impedance. The narrow part of the patch helps the flow from the feed line to the radiating surface. This reduces power being sent back. Improves energy transfer.

The S11 results show that our antenna works better than designs. It is very suitable for communication systems in the C-band. The S11 results demonstrate that the proposed antenna achieves impedance matching compared to conventional designs making the S11 results and the antenna highly suitable, for efficient communication systems operating in the C-band with good S11. Shown as figure 3

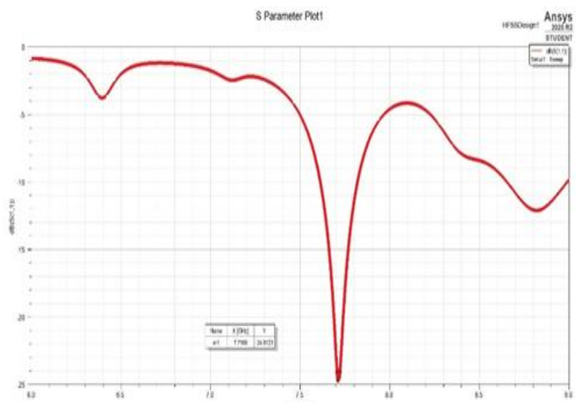

Fig 3 S parameter

The Voltage Standing Wave Ratio or VSWR is a way to check if an antenna is working with the feed line. It helps us see how much power is actually getting to the antenna. When the VSWR is low it means the antenna and the feed line are a team. A VSWR of 1 is the best you can get. If it is than 2, that is usually good enough. The antenna we are looking at has a VSWR of 1.12 at 7.71 GHz. This is really close to 1 so we know it is working well. When the VSWR is low not much power goes back to where it came from which makes the whole system work better. The antenna is doing a job because of its shape. The special shape of the antenna helps power flow smoothly which reduces problems. The thin part of the antenna acts like a helper letting power move smoothly from the feed line to the rest of the antenna. The microstrip feed line was also made carefully to keep its power at 50 Ω. We picked the best spot for the feed line to match the antenna. We did a lot of tests to get the antenna shape right so the VSWR would be as low as possible. The VSWR curve shows that the antenna works steadily at the frequency it is supposed to. This means it will work when we need it to. The low VSWR tells us that the antenna is working well with the feed line and can send power efficiently. This makes the antenna a good choice, for systems that need to communicate by shown as figure 4.

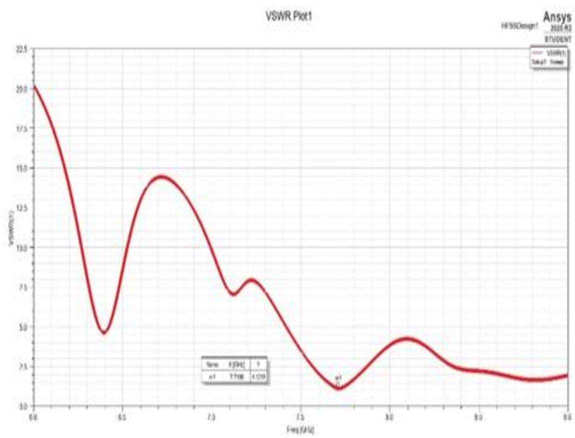

Fig 4 VSWR

Gain is an important factor for antennas. It shows how well an antenna can send power in a direction. Basically gain is a mix of directivity and efficiency. It tells us how good the antenna is at turning input power into energy. For long-distance communication a higher gain is usually better. This is because it makes the signal stronger and improves coverage. The antenna we are proposing has a gain of 2.51 dBi at 7.71 GHz. This gain value means the antenna can provide radiation performance. It is good for communication over a distance. The gain is not super high compared to antennas. However it is acceptable, for microstrip antennas made on FR-4 substrate. The antennas radiation pattern is directional but not too focused. This ensures that the signal is transmitted consistently over an area. The special trophy-shaped design helps achieve this performance. The curved top part improves radiation by spreading out the field. The overall design also helps the flow evenly. We should note that using FR-4 substrate causes some energy loss. This slightly reduces the gain. However our design improvements help make up for this loss. We modified the geometry to improve radiation efficiency. The antenna still performs well despite the material limitations. The gain results show that our antenna balances size, efficiency and performance well. If higher gain is needed we can make the design into an array. Use better materials. Overall the antenna works reliably for satellite communication systems.

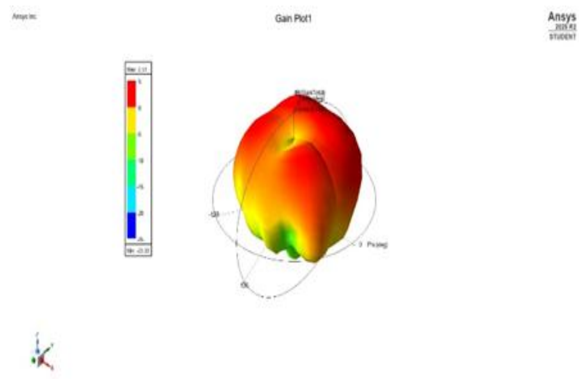

Fig 5 Gain

The simulation results show that the trophy-shaped microstrip antenna works well at the frequency we want which is 7.71 GHz. This antenna does a job of matching impedance, which means it has low return loss and a very good VSWR value. The gain we get is good enough for communication to work properly especially when you think about how small it's the limits of the substrate. The way the antenna is shaped makes a difference in how the current is distributed and how much signal is lost. By making some changes to the design we can get the antenna to radiate signals in an efficient way even though we are using a substrate that is not too expensive. The results show that our design can fix some of the problems that regular microstrip antennas have. The trophy-shaped microstrip antenna is a choice for things like satellite links and wireless data transmission that use the C-band. Maybe someday we can make it even better by using materials or special arrays to get more gain and bandwidth. The trophy-shaped microstrip antenna could be very useful, for these kinds of applications.

V. CONCLUSION

In this study, a compact trophy-shaped microstrip patch antenna has been designed and analyzed to operate in the C-band with a frequency of 7.71 GHz. In the proposed design, the conventional geometry of a microstrip patch antenna is modified by optimizing the current flow inside it to improve impedance matching without compromising the physical dimensions of the structure. The antenna is fabricated on a low-cost FR-4 substrate with excitation through a 50 Ω microstrip feed line. The simulation shows that an antenna with −24.81 dB return loss and 1.12 VSWR is achieved. It demonstrates an efficient performance with respect to radiation due to its gain of 2.51 dBi, making it capable of moderate-range communications. The improved performance of the antenna is due to the proposed trophy-shaped geometry which offers improved electrical path and smoother current flow inside the patch. Although the material used is less efficient due to its losses in high frequency range, the proposed antenna is still able to perform efficiently due to the optimization done in its shape. Thus, it has proved to be an efficient choice in this regard. Due to its enhanced performance, it can be used in applications like satellite communications, VSATs, wireless data transmission, etc.

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