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# 2x2 X-Band Microstrip Patch Array Antenna for Radar Application

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**Abstract—** This project is about designing, analysing, and implementing a 2x2 X-band antenna for radar applications. The design is compacted between 7.5-9.8 GHz X-band frequencies with a maximum gain of 12.5 dB and direct radiation patterns. To improve antenna performance in terms of impedance and profit bandwidth, an air gap with stacked patches is used in the proposed construction. Prior to the detailed analysis the Fr4 material and beyond is used as a substrate due to its availability and low cost. Simulation and analysis are performed with the HFSS (High-Frequency Structure Simulator) simulation tool.

***Index Terms*—10 GHz wideband antenna, automotive radar, radar antenna array.**

## INTRODUCTION

An antenna (multiple horns or horns), or aerial, is an electrical device that converts electrical energy into radio waves, on the contrary. It is usually used with a radio transmitter or radio receiver. In transmission, the radio transmitter provides rotating frequency (radio frequency) (AC)) to the terminals, and the output current emits current as electrical waves (radio waves). At the reception, he says it absorbs some of the electromagnetic force to produce a small voltage at its terminals, which are used on the receiver to amplify it. Pre-communication was only sound but the limit of sound is that it cannot be used to convey a message too far away and it requires a lot of energy and the use of visual cues or pre-dimensional smoke is used for growth. far away because there has been a need for another way for the message to be transmitted to a greater extent and here the electromagnetic radiation comes well and plays an important role and the antenna pole is a tool that uses this source effectively. An antenna is a device that emits electromagnetic radiation and also detects electromagnetic radiation.

Conventional antennas have high efficiency and good radiation at a good distance but have a small bandwidth and large size which is a major disadvantage of modern conventional horns. Microstrip patch array antenna as it is very compact in size and high gain can meet all device requirements and large bandwidth with microstrip patch array antenna we can reach any required bandwidth with patch antenna only by controlling the size and shape, type of supply, placement. way, etc.

There are basically three main components for building microstrip patch array Radiating patch (metal conductor), Substrate (usually dielectric material), Ground (metal conductor), radiating patch set in addition to the PCB responsible for power output. It is connected to the feed to the antenna directly and has good polarity. There are several types of patches. Based on the system we use antenna size and the shape of the pool is determined.

Substrate dielectric material can be anything that has no electrical properties but can pass through electricity directly into it. It is a measure of the approval of a property against electric waves. Dielectric Equipment, Its dielectric coefficient plays an important role indicated by (εr). In this type of antenna for the microstrip patch array, the microstrip is directly connected to the circuit with a power supply that alternates with time given to the pool and leads to radiation.

An antenna can be categorized based on its size, advantage, radiation, and the type of feed used to stimulate fire antennas, dipole antennas, microstrip patch array antennas. The antenna emits radiation when a rotating antenna is used in its input feed if there is no timing antenna, the antenna will not emit radiation. It is currently supplied by supplying current to the feed area connected to the antenna sections by a microstrip patch made of copper hence the name microstrip patch array antenna.

To provide power supply to the antenna a variety of feed methods are used such as microstrip line feed, coaxial feed, integrated feed hole, proximity coupled feed.



The performance of the antenna plays an important role when the antenna rod is part of a complex embedded system as low performance may affect the overall performance of the system. Various antenna parameters to be kept under consideration of radiation pattern, return loss, gain, direction, bandwidth, antenna efficiency.

The advantage of using such a 2x2 microstrip patch array antenna is that these horns are much simpler and have a much smaller volume compared to a conventional antenna which is much stronger in construction when used in a fixed position and has very low production costs. and is very helpful in all aspects. The disadvantages of using an antenna are that it has very low bandwidth, is low efficiency and cannot handle high power inputs, and has a low advantage compared to other conventional antennas.

## PROPOSED ANTENNA DESIGN

Antenna design is a 2x2 patch antenna. The proposed antenna consists of two spreadsheets of substrate material to which the patch is attached. Here is the substrate. The materials used are FR4 with a thickness of 0.8mm and the clip is made of copper. It also has a size of 8.2mm Due to its better performance and ease of access. The above substrate contains 4 square squares of copper that are not connected. The substrate below also contains 4 interlocking copper pockets. Both substrates are separated from each other with the help of a stand-up. Allowing the design to have air space which increases the gain and performance of the antenna

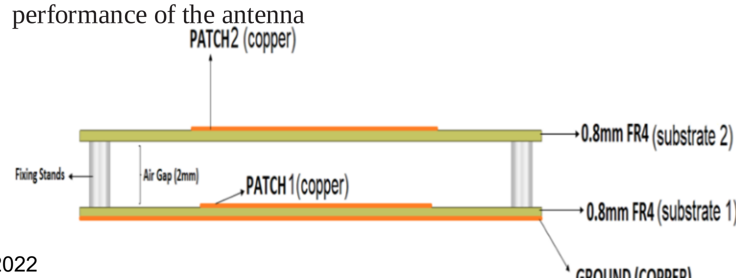



**Fig. 1: Patch Array Antenna with Air Gap**

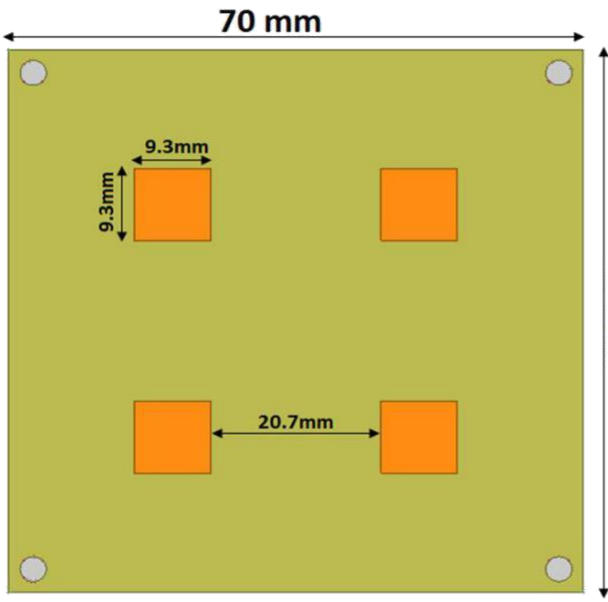



**Fig 2: Top view of the antenna**

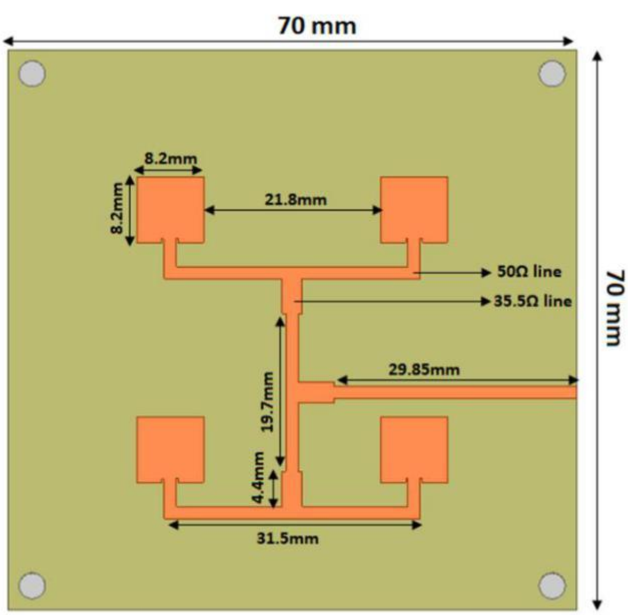



**Fig 3: Bottom view of the antenna**

## MEASUREMENT AND ANALYSIS

Patch Calculation:

$L=L\_eff-2\Delta L$ …................. (1)

$L\_eff$ = Effective length, and it is given by $L\_eff=c/(2f\sqrt{(\varepsilon\_reff)})$ …..................... (2)

Where, C= velocity of light ($3\times10^{11}$mm)
f = Resonant frequency
L= length of the patch
$\varepsilon\_r$= Dielectric constant of substrate

Normalized extension in length:

$\Delta L=0.412h\,(\varepsilon\_reff+0.3)(w/h+0.264)/(\varepsilon\_reff-0.258)(w/h+0.8)$…................... (3)

Where, $\varepsilon\_reff$ = Effective dielectric constant, and the equation for it is given below
$\varepsilon\_reff = (\varepsilon\_r+1)/2+(\varepsilon\_r-1)/2\,[1+12\,h/w]^{((-1)/2)}$

## ANALYSIS:

**Return loss:** When attaching, he says, loss of recovery is an important factor to consider. It is a way of describing input and output of signal sources. Comparisons of impedance and magnitude of energy theory transmission are linked to loss of recovery. If the load is different, not all available generator power is transferred to the load. This recurring loss is also a measure of the antenna's ability to transfer power from the source to the pole. The return loss, RL, indicates the signal strength displayed in dB relative to the incident signal. The power rating of the antenna pin in the power from the so-called Pref source you define. The Pin / Pref ratio should be high to transmit active power. If the loss of the reversal is modest, the occurrence of static waves or resonance may improve, leading to a frequency or gain gain. The loss of return is a response determined from the size of the S11 compared to the frequency during the design phase of the microstrip pool antenna. For most active circuits, a loss of 10 dB is sufficient.

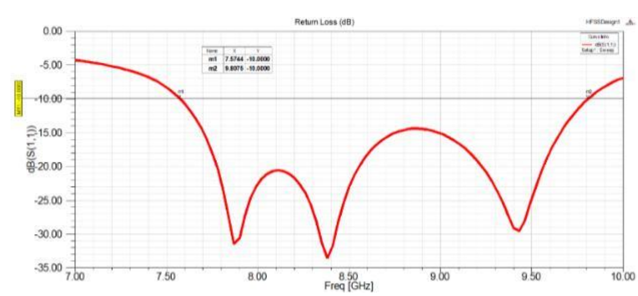



**Fig 4: Return Loss**

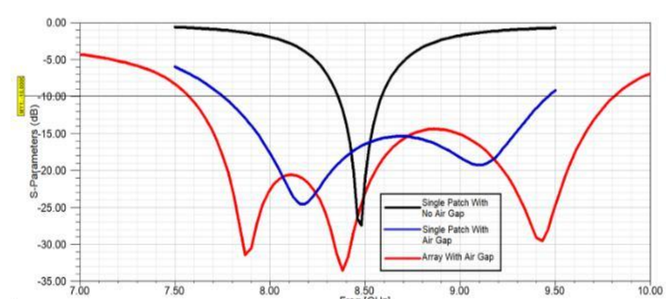



**Fig 5: Return loss comparison for single patch array antenna without air gap, single patch with air Gap, patch array antenna with air gap are shown below.**

## GAIN

Gain is a useful metrics for demonstrating antenna performance. Although the gain of the antenna is closely related to directing, it is a metric that considers the efficiency of the antenna and its directional power. The gain of the antenna is usually expressed in decibels (dB), which simply refers to the highest radiation exposure.

The following graph compares the gain of a single air antenna with an air gap, a single air antenna with an air gap.

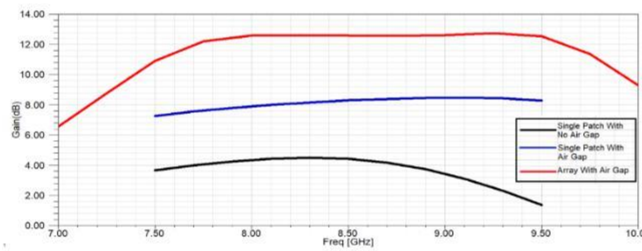



**Fig 6: Comparison of gain of the antenna between single patch with no air gap, Single patch with an air gap, and the array antenna with an air gap.**

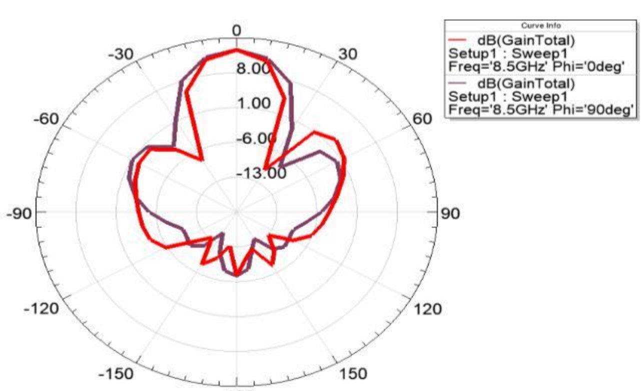
From the above, the analysis can clearly be seen that the gain vs frequency of the Patch antenna for the air gap system is the highest and the worst gain with a single air gapless Patch.

## RADIATION PATTERN

The energy released or received by the rainbow is equal to its angular surface and radial distance from the source. The radiation pattern is best illustrated by a three-dimensional force graph against elevation and azimuth angles, although it is usually represented by E-plane or H-plane where one angle does not change while the other is variable. The radiation pattern is defined as "a clear picture of the antenna radiation properties as the function of the local coordinates." The dynamics of power fluctuations, radiation intensity, field strength, and direction are all examples of radiation properties. "

The radiation pattern at 8Ghz is shown below

**Fig 7: Radiation Pattern at 8 GHz**



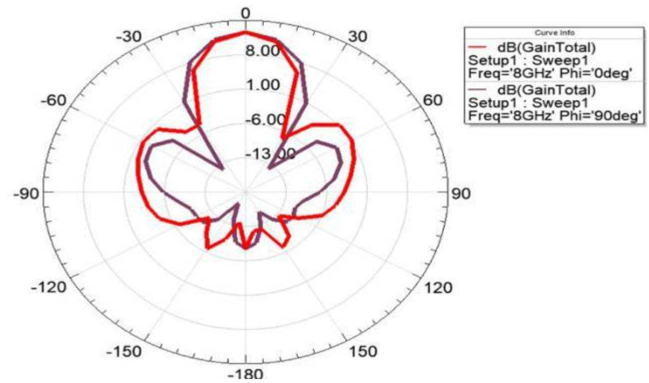




**Fig 8: Radiation Pattern at 8.5 GHz**

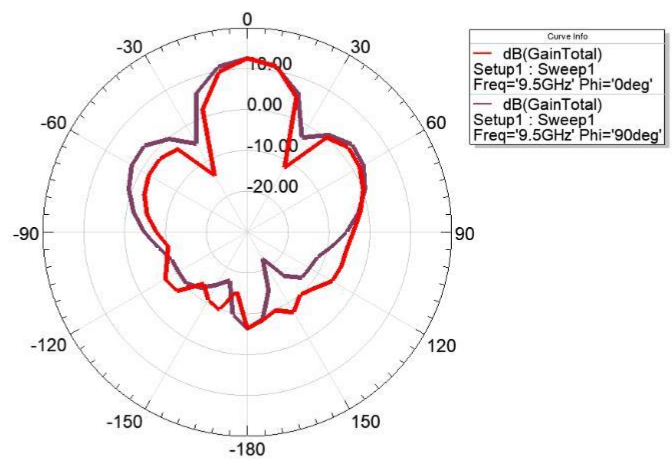



**Fig 9: Radiation Pattern at 9 GHz**

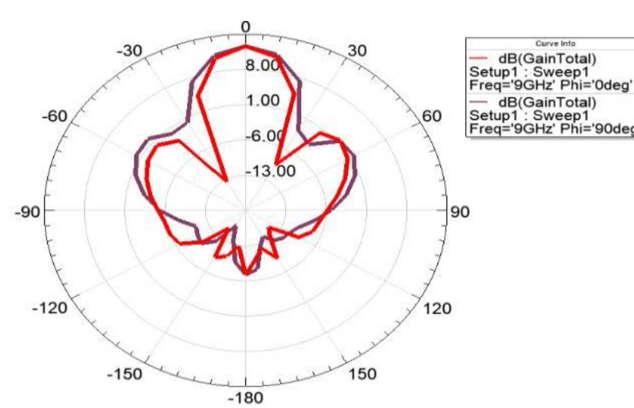



**Fig 10: Radiation Pattern at 9.5 GHz**

| Design | Frequency Range (GHz) | Bandwidth (GHz) | Peak Gain (dBi) |
|---|---|---|---|
| Single Patch Antenna with no airgap | 8.36-8.58 | 0.22 | 4.4 |
| Single Patch Antenna with airgap and stacked patch | 7.76-9.46 | 1.7 | 8.2 |
| Array Antenna with airgap and stacked patch | 7.5-9.8 | 2.3 | 12.5 |

## CONCLUSION

In this project, we have come to the conclusion that the air gap between the substrates can improve antenna gain. To compare the proposed antenna performance with other substrate materials, the antenna is built with materials such as FR4. For proper comparison between all the horns, When comparing the performance of a stick, it is observed that the advantage of a pole designed using a 2x2 patch rod with air space, due to its low dielectric value does not change. From the analysis, it can be concluded that substrate materials with a fixed dielectric will provide high gain, but patch size will be high, and substrate materials with high dielectric will always provide low gain, but patch size. will below. Therefore, when a more efficient antenna is needed, low-density dielectric substrate materials may be used, and when low-profile antenna is required, high-density dielectric substrate materials may be used.

From this particular design, it can be concluded that a single airless antenna antenna has a maximum frequency of 8.58 GHz and a single air gap with a maximum frequency of 9.46 GHz but a 2x2 patch antenna has a very high frequency. 9.8 GHz which is the maximum of three.

In terms of bandwidth, you have a total bandwidth of 2.3 GHz and the advantage of the most important feature. The 2x2 patch array antenna has the advantage of all three which is 12.5 dB which is much higher than 4.4 and 8.2 GHz. Therefore, the proposed design is a complete development of antenna parameters.

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