High Gain Microstrip Antenna Designs for A Doppler Radar

Emre Nedim Hepsağ, Ahmet Yasin Bulut and Fatih Yaman

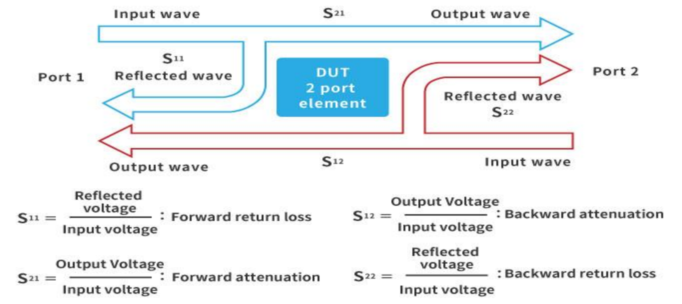
Izmir Institute of Technology, Izmir, Turkey

Abstract

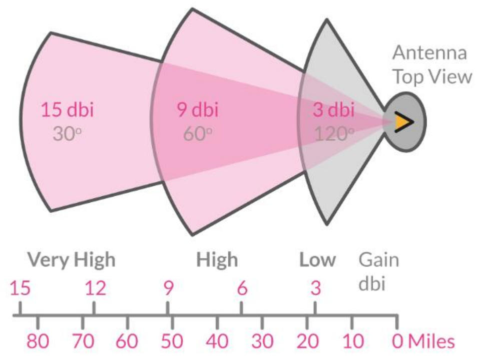
- ✓ There are various microstrip patch antenna structures with different features. However, it is not clear that which one has most suitable characteristic features for doppler radar.
- ✓ Therefore, we tried to figure it out by comparing some significant array structures. We designed our structures to match for 5.8GHz, optimized their radiation patterns on CST Studio Suite and aim for high gain main lobe with no side lobes.
- ✓ Our results show that 1x4 patch array has by far best directivity for a doppler radar. By producing the antenna with PCB producing method of UV exposure, measuring the S11 at network analyzer and testing it with gain transfer method in an anechoic chamber at IZTECH, we observed that the simulation results are consistent with our measurements.
- ✓ We conclude that to design a proper microstrip patch antenna for a doppler radar, 1x4 patch array is the only preferable one among others.

Introduction

- ✓ Printed antennas have interesting features for realization. They are easy to manufacture, they have low weight, and they are small. They are durable, compact and also cheap. We can see them in radars, mobile phones, satellites or gps systems.
- ✓ Microstrip antennas are the most popular printed antenna type, they have dielectric material on the middle which separates the patch and the ground conductor.
- ✓ At simulations, we are concerned with S11 parameter, and it is just negative of return loss. We aim our operating frequency to be lower than -10dB at S11 which describes bandwidth of an antenna.



- ✓ In a Doppler Radar implementation another important parameter is the radiation pattern. It shows the direction of radiated power far from the antenna. From this pattern, we can observe the gain and directivity.
- ✓ The directivity shows the radiation direction, mainly on high gain direction. In a doppler radar application like we planned, the antenna must be focused on one direction, and this must be narrow for not radiate to other objects or receive signal from side directions.
- ✓ Also, the back lobe of the pattern can reflect and affect the front main lobe, so we need to decrease the side and back lobes in optimizing the directivity in our application.
- ✓ Gain is the parameter of the transmitted power in terms of direction compared to isotropic antenna which is a theoretical antenna. Simply, when a radiated energy concentrated instead of spreading, our gain increases because we intensify the radiation on the direction. Gain is proportional to efficiency and physical aperture area.



Methodology

The approximated width can be calculated from:

$$W = \frac{v_0}{2f_r}\sqrt{\frac{2}{\varepsilon_r + 1}}$$

The fringing edges cause a change on the dielectric constant, so the effective dielectric constant is:

$$\varepsilon_{eff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2\sqrt{1 + \frac{12h}{W}}}$$

Next, we need to find our length of the patch, but because of the fringing effect, we first need to calculate the fringe factor by the equation of:

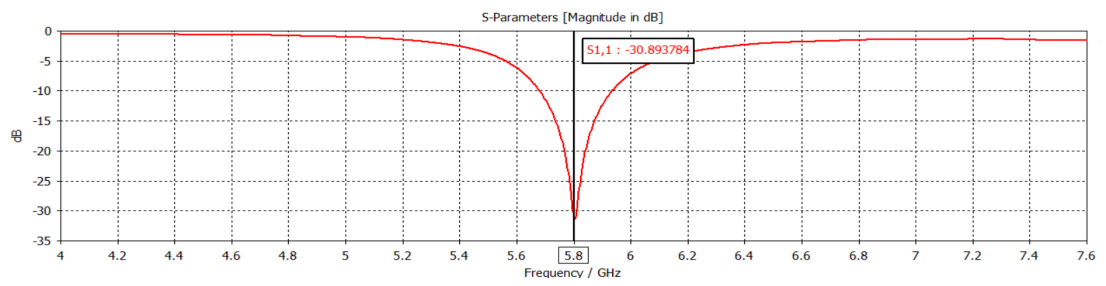
$$\frac{\Delta L_{eff}}{h} = 0.412\frac{(\varepsilon_{eff} + 0.3)\left(\frac{W}{h} + 0.264\right)}{(\varepsilon_{eff} - 0.258)\left(\frac{W}{h} + 0.8\right)}$$

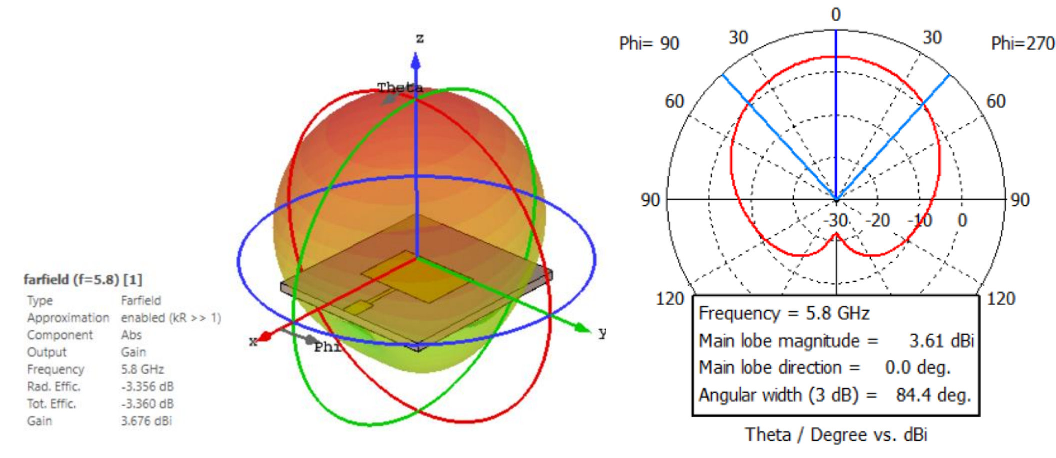
To calculate actual L:

$$L = \frac{c_0}{2f_r\sqrt{\varepsilon_{eff}}} - 2\,\Delta L_{eff}$$

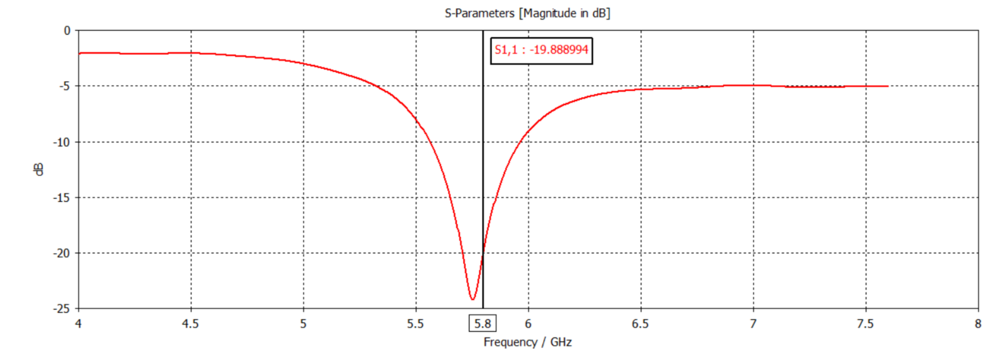
Antenna Designs

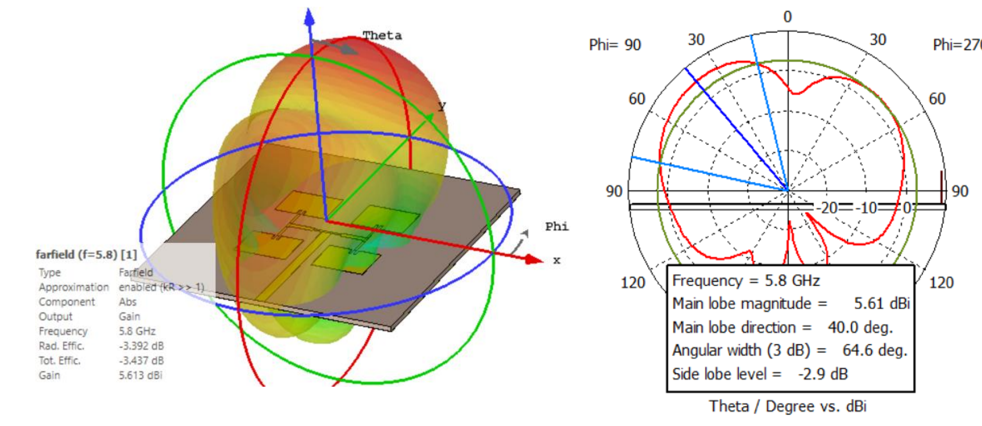
✓ First 1x1 Patch



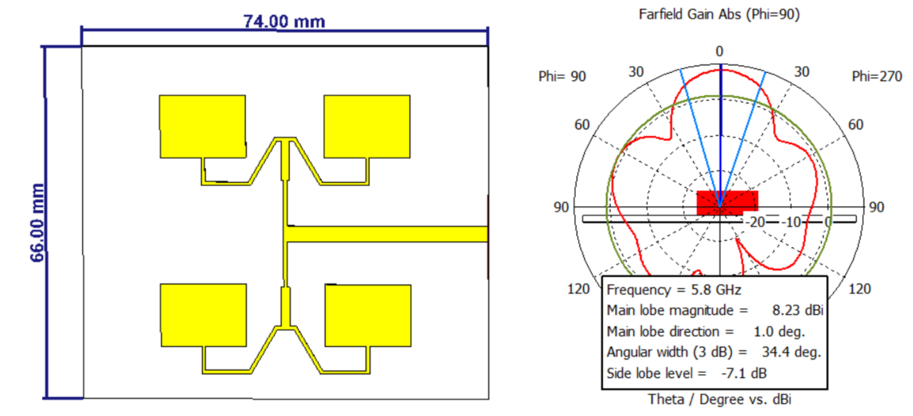


✓ First Antenna Array - 2x2 Patch

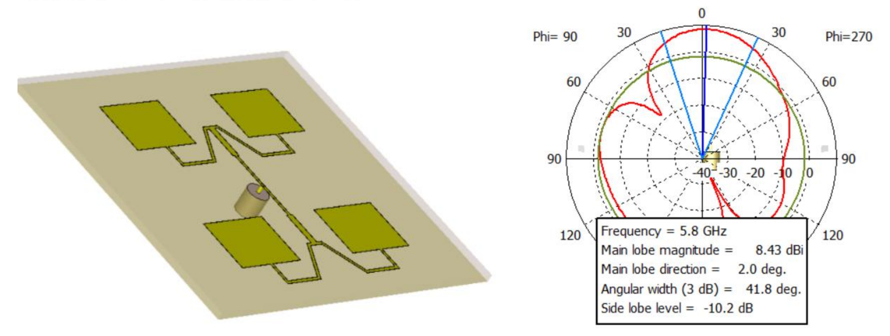




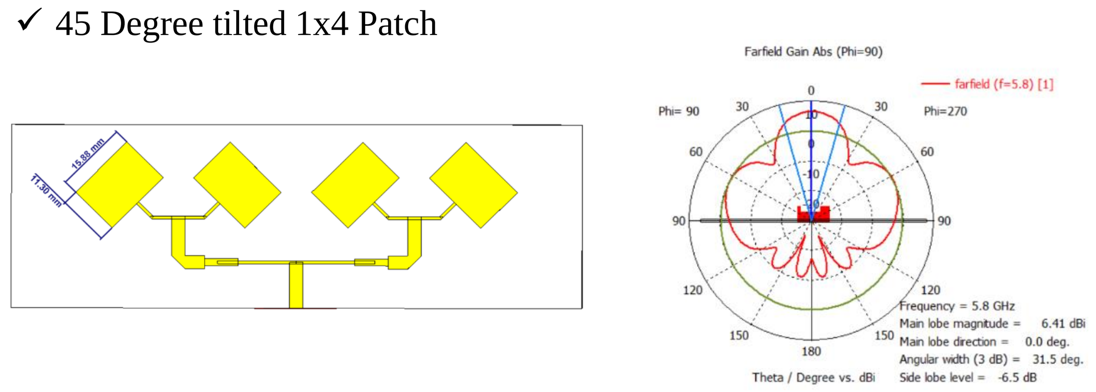
✓ Side Feed 2x2 Patch



✓ Coaxial Feed on 2x2 Patch

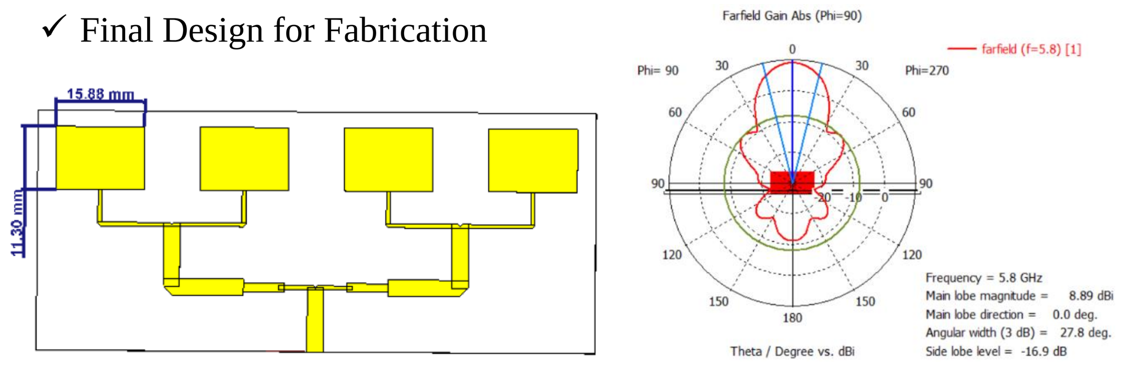


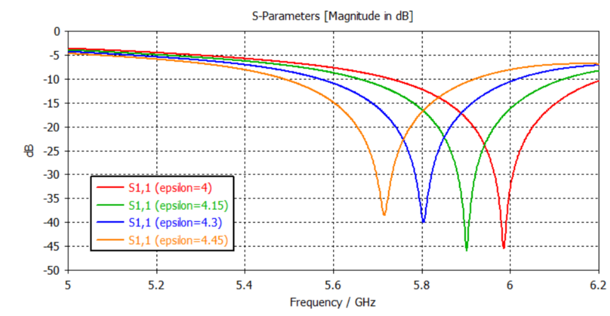
✓ 45 Degree tilted 1x4 Patch

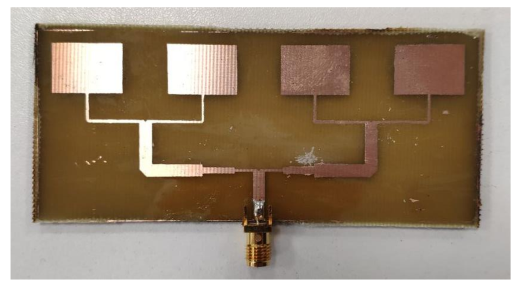


Fabrication & Test Process

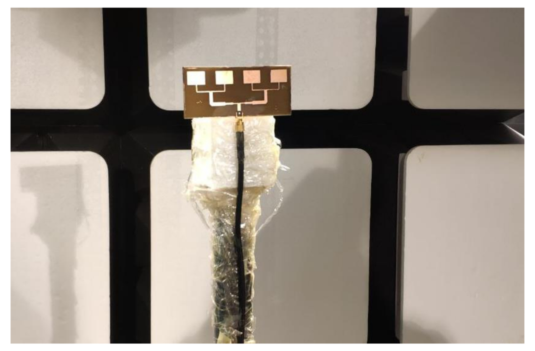
✓ Final Design for Fabrication

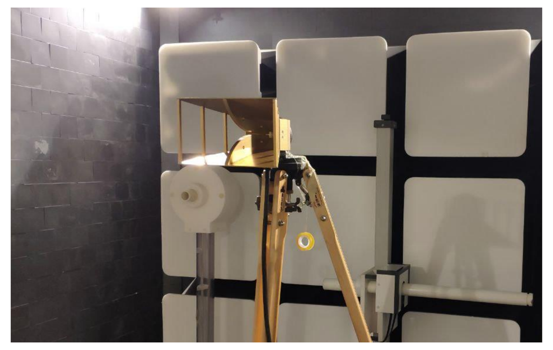


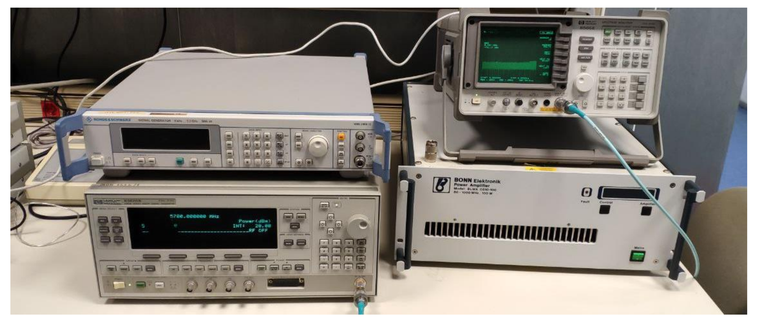




✓ Anechoic Chamber Tests & Measurements

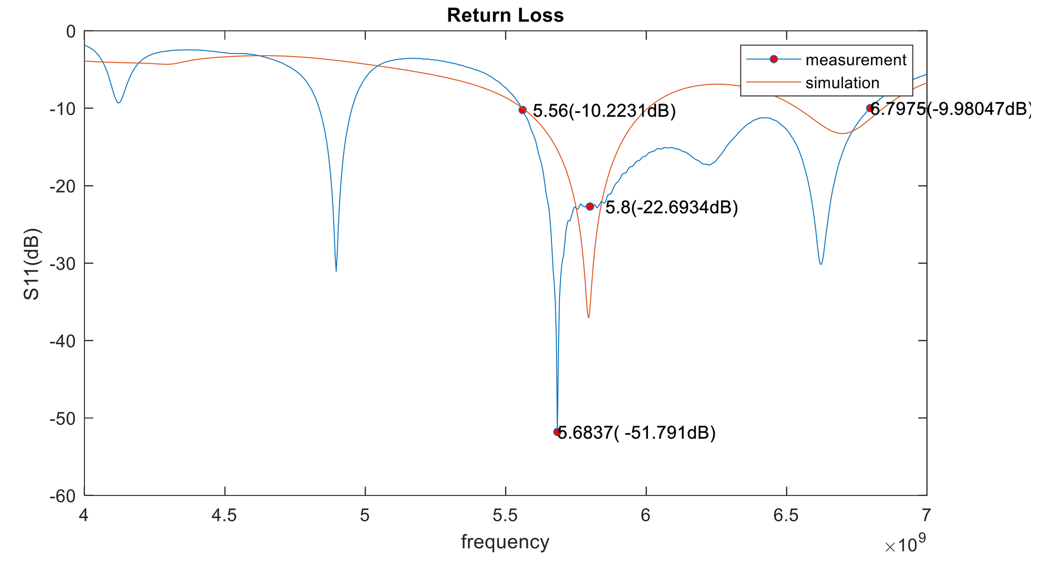




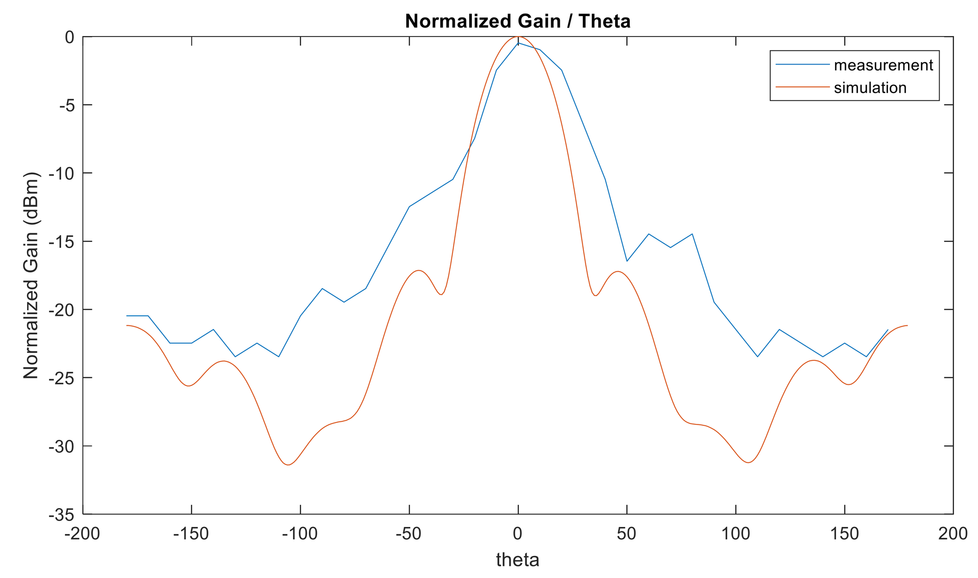


Results

✓ Return Loss comparison of measured and simulated plots



✓ Gain comparison of measured and simulated plots



Conclusion

- ✓ 20dB return loss is enough for our antenna desing and other parameters such as gain and directivity has greater importance for doppler radar production.
- ✓ Rather than theoritical calculation, iterative simulation trials are more important to tune the antenna and improve the parameters.
- ✓ S11 parameter of our antenna has shifted 100MHz, but it has distinct similarities with our antenna mainly on our focus area of 5.8GHz. We saw that it was not needed to produce professionally by PCB machines, and UV exposure method gives good fabrication results.
- ✓ For anechoic chamber tests, a reference antenna is needed. We used a horn antenna with 12dBi gain.
- ✓ As the main aim of the Project, we ended up a properly working 5.8GHz microstrip antenna for doppler radar implementation. For the future work, we want to use this antenna with a Vivaldi antenna for test and comparison of 2.45GHz and 5.8GHz doppler radars.

Reference

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