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Optimization and Evaluation of Mitered-Bend Feeding Network in Linear Array Microstrip Antennas for X-Band Radar Systems

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ABSTRACT- Using this antenna, we can precisely detect minute objects, such as raindrop particles. Utilizing a linear array antenna, we are increasing the system's gain. The X-band radar uses the electromagnetic spectrum and has a frequency range of 8 GHz to 12 GHz. With the proper antenna requirements, X-band radar can be used for maritime radar with ship navigation capabilities as well as weather radar. A microstrip antenna with a unidirectional pattern is necessary for the x-band radar application as a ship navigation instrument. The system is incredibly sensitive to small objects. Miterbends are employed for better impedance matching. The use of miter bends reduces the reflection coefficient. This study limits radiation to up to 8 elements and then includes a method to widen the bandwidth of antennas. Taking into account the lifetime and material restrictions of the antenna design. The finished antenna is 142.40 mm x 42.8 mm in size. According to the measurement results, the antenna is linearly polarized, has a unidirectional pattern, and has the following specifications: fc = 9.496 GHz, S11 = -32.64 dB, VSWR 1.05, bandwidth = 41.9 MHz (9.5159 GHz - 9.4740 GHz), and gain 8.8 dBas. The radar antenna typically has a narrow beam and a high gain.

KEYWORDS- Linear Array, Micro Strip Antennas, Mitered-Bends Feeding Network, X-Band Radar Applications

I. INTRODUCTION

In the realm of modern communication and radar systems, the design and performance of antennas play a pivotal role in ensuring the efficiency and accuracy of data transmission and reception. The X-band radar frequency range, which spans from 8.0 to 12.0 gigahertz (GHz), is widely utilized in applications such as weather radar, military radar, satellite communication, and airborne surveillance. In these applications, the performance of the antenna system is of utmost importance as it directly affects the overall functionality and reliability of the radar system [5]. This paper delves into the realm of linear array microstrip antennas with mitered-bends feeding networks, particularly tailored for X-band radar applications, with a focus on design, analysis, and performance evaluation.

X-band radar systems are favored for their capability to provide high-resolution imagery and precise target detection. They are particularly critical in military and aerospace applications where accuracy and speed are paramount. To harness the full potential of X-band radar, the antenna system is crucial. Antennas designed for X-band radar applications need to possess certain characteristics, such as high gain, wide bandwidth, low sidelobe levels, and efficient power transfer. Achieving these attributes is a formidable challenge, but it is an endeavor that has driven the evolution of antenna technology [6][7].

Linear array microstrip antennas have emerged as a viable solution for addressing the stringent requirements of X-band radar applications. These antennas offer several advantages, such as compactness, low profile, and ease of fabrication, making them well-suited for various radar systems. The mitered-bends feeding network is a key component that can significantly enhance the performance of these antennas. It ensures efficient power distribution across the array elements, resulting in improved gain and radiation pattern characteristics.

The primary objective of this research is to investigate the design and performance analysis of linear array microstrip antennas with mitered-bends feeding networks tailored for X-band radar applications. In doing so, we aim to address some of the critical challenges and requirements of modern radar systems:

Compact and Low Profile Design: In many radar applications, space constraints are a challenge. A compact and low-profile antenna design allows for integration into platforms with limited real estate, such as airborne or satellite systems.

II. LITERATURE REVIEW

Rajasekhar Manda et al. [1] design antennas for similar operations at this frequency must have lower weight and good characteristics. For this, grapheme is the stylish suitable material for design due to its electrical, optic, and thermal conductivity parcels. So, the Graphene- Grounded drilled substrate patch antenna 500 X 500 X 40 μm presents the simulation in the terahertz frequency. The proposed antenna structure is well suitable in the ISM (Industrial Scientific and Medical) band1.36 THz-1.64 THz2.4 25 GHz. Its gives a high gain-20 dB.

Alsager et al. [2] design a compact blockish patch antennas are designed and tested for GPS bias at1.57542 GHz, and for a satellite television signal at11.843 GHz and11.919 GHz. The final part of this work has been concentrated on studying an array antenna with two and four rudiments. The antennas of the design exemplifications of this work has been manufactured and tested in laboratory.

Putri etal.[3] studied the limits up to 8 rudiments of radiation, followed by the addition of a system to expand the bandwidth of antennas. Considering material limitation and duration of antenna design. The final antenna confines are142.40 mm ×42.8 mm. The measuring results show fc = 9.496 GHz, S11 = -32.64 dB, VSWR1.05, bandwidth = 41.9 MHz (9.5159 GHz-9.4740 GHz), and gain8.8 dB as well as a direct concentrated antenna with unidirectional pattern direction. The radar antenna tends to have a narrow beam width and high gain.

Rakha etal. [4] proposed a blockish microstrip patch antenna with disfigurement Ground Structure(DGS) operating in the X-band around 5 GHz was developed for excrescence detection. The antenna was designed with confines of23.72 ×29.78 ×1.588 mm3 and a Roger- RT/ 5880(εr = 2.2) substrate material and a blockish feed- line was used to supply the antenna's radiating patch. The design dealt with a single element and an array of rudiments in order to im- prove performance compared to preliminarily published exploration.

III. PROPOSED SYSTEM

This paper will show the design and time domain analysis of a rectangular patch array antenna. To operate at ultra-wideband frequencies, the antenna is built using FR4 substrate with a high dielectric strength of 4.4. It also comes in a small size and design. A co-planar waveguide transmission line supports the antenna, which is smaller overall.

Antenna analysis was formerly performed manually or visually, but more recently, new software has been developed to make the process simple so that ultra-wide band antennas can be used in a range of everyday applications. Applications for wireless antennas are becoming more common in daily life as a result of their higher versatility. Numerous wireless gadgets, such as laptops, tablets, smart devices, smartphones, and other comparable wireless devices, are included in these applications. We find antenna applications to be increasingly fascinating as we do more research on them.

$$\text{Bandwidth X } \log(1 + \text{SNR}) = \text{capacity}$$

Wireless antenna are more frequently used in applications in daily life as a result of their more adaptable character as shown in Figure 1. Antennas have a wide range of applications, including in biomedical settings and in wireless technology found in computers, tablets, smart devices, and mobile phones. There is a rising demand for printed flexible antennas. Numerous wireless applications are available based on tiny geometric meta-material. Micro strip antennas are easy to construct, enjoyable to use, and require less manufacturing expense for Ultra Wide Band antenna analysis and design. Wireless and flexible electronics require ultra-wide band technology, or UWB in Figure 2.

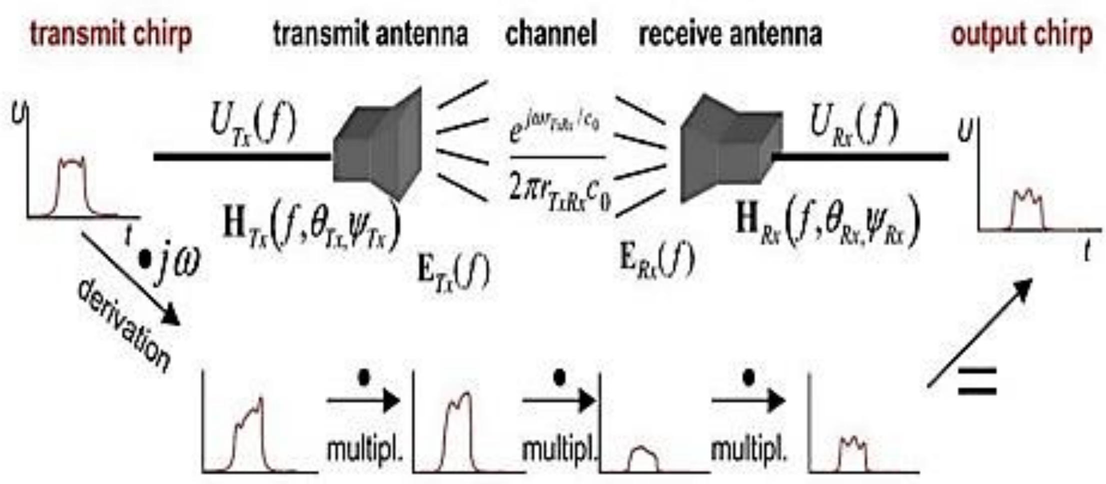

Figure 1: Signal transmission and reception

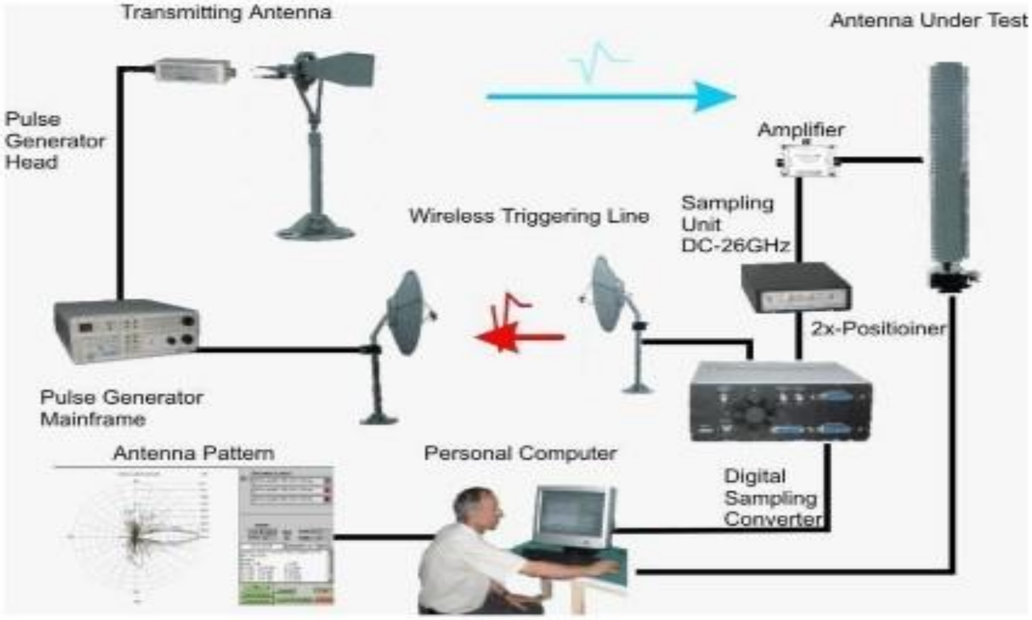

Figure 2: Testing an antenna

IV. RESULTS

The simulation results will show the parameter value of the antenna design performance, giving a broad grasp of the antenna performance. Measurements are made when the antenna is constructed, but the likelihood of departure is not considered. This results in a tolerance limit for the derived antenna parameters. The antenna will be positioned optimally utilizing simulated software to design it.

The arrangement's return loss S-parameter. This antenna array showed a good return loss of -22.33 dB for modeling results and -32.64 dB for testing data at 9.5 GHz resonant frequency. Comparison of the simulation with the -10.31 dB measurement. This antenna met the anticipated antenna requirements of fc = 9.5 GHz and S11 20 dB. Simulated data indicates that the X-band antenna in the frequency range is capable of generating multiband frequencies. Frequencies in the 4.1GHz range have been detected. The frequency ranges below -10 dB are known as the working band.

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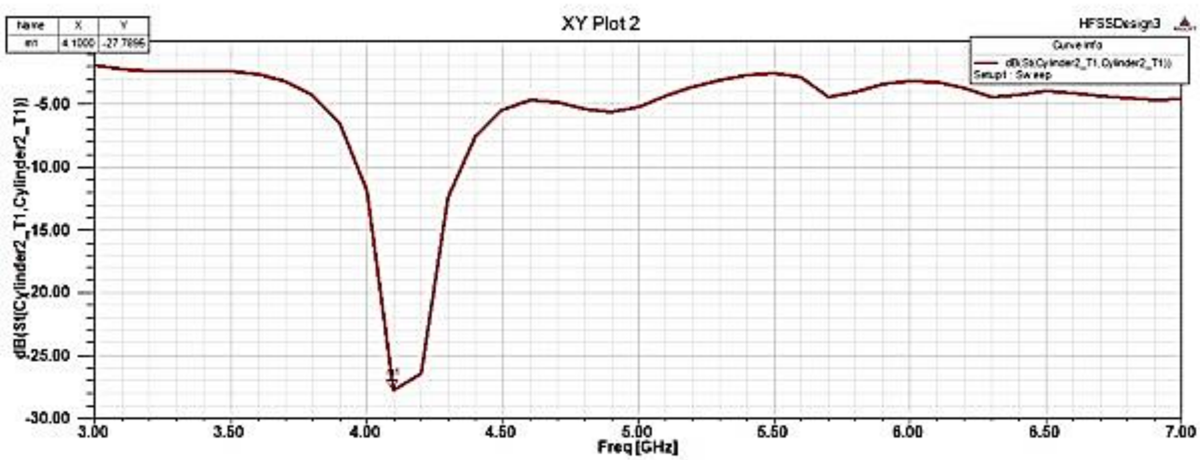

Figure 3: S-parameter Analysis

You can observe the graph showing the comparison of the VSWR values between the simulated and measurement data. The outcomes of the simulation point to a VSWR of 1.16. Both numbers fell inside the allowed VSWR range (VSWR 2.0), despite the fact that the VSWR measurement result was 1.05. The channel is in its optimum state when the VSWR is 1 (=), it prevents contemplation [3]. The optimum antenna matching condition can be difficult to achieve, hence the VSWR value should be smaller than (2.0). VSWR measurements are taken to find the waveform of the reflector signals as shown in Figure 3 & 4.

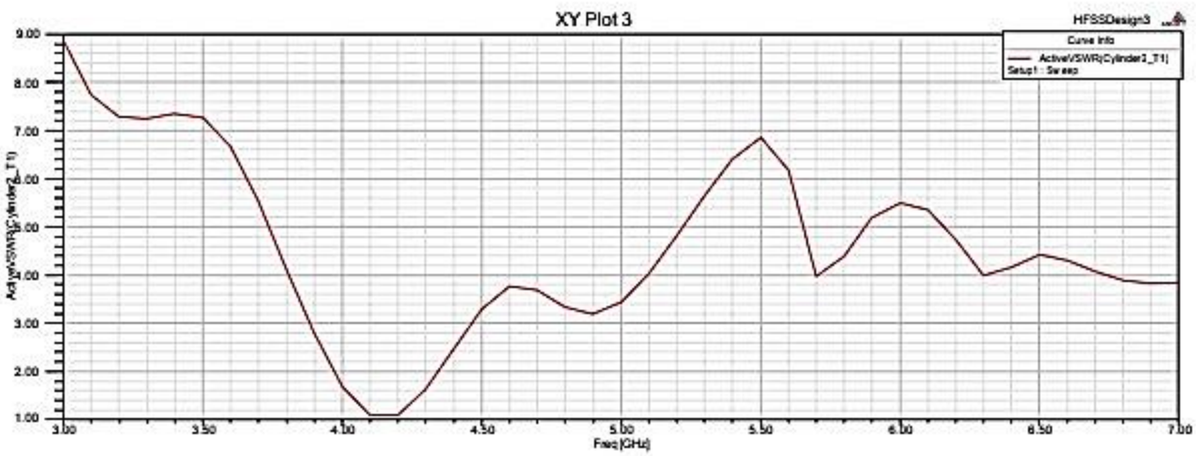

Figure 4: VSWR parameter analysis

Pref (dBm) is the power level receive antenna reference, PAUT (dBm) is the power level the AUT receives, and Gref (dBi) is the gain antenna references. The measured antenna gain is GAUT(dBi). Thus, the antenna prototype's gain value of 8.8 dB is known. The antenna's gain is 15.7 dB. The antenna prototype can only achieve a gain of 50.1% through simulated reinforcement..

V. CONCLUSION

The antenna used in this project is an array of eight microstrip antenna elements with an operating frequency of 9.5 GHz. Based on the outcomes of the design, antennas showed that the array technique might increase the gain. around 5 dB more gain on a design. an antenna employs the miter-band feeding network method to build an 8 component antenna array, which is a significant departure from previous studies. The 480 MHz bandwidth of the final antenna design, which employed the mitered-bends method, is greater than the 450 MHz bandwidth of the earlier design. The antenna radiates in a single direction and has linear polarization. The antenna already generates good characteristics and conforms to the necessary standards, according to simulation results.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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