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Research Article

Multi-Antenna Utilized Strategy For Radar Based Applications

B.Nataraj*,K.R.Prabha
Department of Electronics and communication Engineering, Sri Ramakrishna Engineering college, Coimbatore
*nataraj.b@srec.ac.in

ABSTRACT

This proposed methodology contemplates a rectangular form of micro-strip patch antenna was intended for radar application at an functional frequency of 9.6 GHz. The multi-antenna is made up of four radiating patch elements. The layer height is 1.6mm and the dielectric constant is 4.6. This multi-antenna is made up of four radiating components. This architecture makes use of radiating elements to maximize gain and directivity. We selected the FR4 substrate with a Dielectric constant of 4.6, Height of 1.6mm, and Loss Tangent of 0.018 for the specification since it is compared to the frequency spectrum to get the best performance. The FR4 substrate was selected for its cost and performance reliability. The multi-antenna's gain and directivity have been improved for this design. The multi-antenna is designed and simulated using the Advanced Design System software platform.

Keywords: Microstrip patch antenna, Radar application, microstrip patch multi-antenna, X band Radar frequency, Advanced design system software, Momentum, Radiation pattern.

Introduction

In modern times the demand for radar has been originating exceedingly through employing variety of techniques. RADAR is a method for determining the location, angle, and velocity of moving or stationary targets by using electromagnetic waves. Ships, airplanes, guided missiles, atmosphere conditions and other phenomena will all be detected with this technology. In the world of RADAR systems, antennas play an integral role. This technology is used for long distances communication such as satellite communication. Long-distance connectivity, such as satellite communication, is allowed by this technology. The system uses electromagnetic waves to track, measure distances, and build contact artifacts. A waveguide of 8 to 12 GHz should be used for the radar frequency. The antenna was built with a compact antenna size and light weight in mind, taking into account the antenna's reliability as technology advances. In a radar application, an antenna device is critical since the antenna serves an essential communication function. The antenna is created by choosing the appropriate substrate, such as FR4. The layer has a dielectric constant of 4.6 and a height of 1.6mm.. For obtaining the radiation pattern and simulated graph, the simulation process is carried out in the Advance modeling method software tool. Micro-strip technology is critical for antennas that are compact in bulk, light in weight, and simple to fabricate at a low cost. The architecture of a micro-strip patch antenna is ideal for radar use due to all of the characteristics. Because of its high directivity and polarization, a rectangular form patch is considered. An antenna with a rectangular outline is strongly Omni-directional. For improved results, a Micro strip patch multi-antenna optimized for Radar with four radiating elements patch antenna in-array was introduced. Instead of using a single antenna, a four-multi-antenna is used to maximize gain and directivity.

Literature Review

A unique way of literature survey has been carried out in this paper for reference purposes to obtain the best results.

Ashikur Rahman et al[1]demonstrates the output of a wideband microstrip patch antenna for RFID applications in ISM. The substrate is made of Flame Retardant-4 (FR-4) material. At the ISM band, the output of the proposed antenna is analyzed and compared to that of various RFID reader antennas. CST Microwave Studio is used to plan and simulate it. VasujadeviMidasala et al[2] demonstratedthe 3x3 rectangular multi-antenna to work in the Ku Band. The antenna was constructed as a patch arrayand feeding currents optimised to meet the requirements of low side lobe and good cross polarisation.The return loss, 3D polar map, Directivity, VSWR, and Gain of the antenna are computed using the FEM-based HFSS 14.0. The results of the software simulations show that the proposed multi-antenna performs well in terms of return loss, VSWR, and gain.

Asif Ali Bhoot et al[3] demonstrates that the microstrip patch antenna (MPA) is the first option for wireless communication systems due to various advantages such as ease of configuration, low weight, and low cost. They compare and contrast the output of four different formed antennas. E, T, H, and F are the shapes that are considered. On various frequency bands, the effects of various antenna parameters such as return loss, VSWR, radiation pattern, gain, and directivity are analyzed.The antenna simulation tool High Frequency Structure Simulator (HFSS) is used.Anjaneyulu Gera et al[4]demonstrates therectangular patch array antenna for satellite applications. The multi-antenna is designed to operate in the 12 GHz frequency range. Since it is easier to fit the impedance with the inset feeding system, it is used for the patch. On an RT Duroid 5880 dielectric substrate, a single element patch antenna with optimal output is constructed, as well as a two-element and four-element linear array with the same dimensions.The four-element array resonates at four different frequencies between 10 and 13 GHz, with a modest gain for S11 > 10 dB, according to simulation performance.YudiYuliyusMaulana et al[5]demonstrated that the rectangular Patch Multi-antennas are numerically and experimentally explored. This antenna is designed for radar applications and operates at a frequency of 9.4GHz. The 1x16 patch multi-antenna is used to build multi-antennas, and the patch antenna is implemented using microstrip lines.

The survey listed above show various antenna design concepts. Several approaches have been investigated based on the antenna's shape, design parameters, resonant frequency, dielectric constant, gain, directivity, and return loss. In comparison to those articles, the proposed model performs better and is more accurate.

Methodology

A.RADAR

Radar is a type of tracking technology that uses radio waves to determine the length, angle, and velocity of an object. A radar system consists of a transmitter that produces electromagnetic waves in the radio or microwave frequency spectrum, a transmitting antenna, a receiving antenna, and a receiver and processor that calculates the properties of the target. The radio waves from the transmitter knock off the target and return to the receiver, supplying information on its location and speed.

B. RADAR COMPONENTS

The radar's working principle is very basic since it transmits electromagnetic power and analyses the energy returned to the target. A barrier is in the way of transmission if the returned signals are received at the same position as their source. The following is the operating principle of radar.

The following are the key components of this framework:.

- **A Transmitter:** In transmitter it's possible to use a power amplifier like a Klystron, a Traveling Wave Tube, or a power Oscillator like a Magnetron. The signal is produced by a waveform generator and then amplified by the power amplifier.
- **Waveguides:** A waveguide is a structure that directs waves, such as electromagnetic waves or sound waves, with reduced energy loss by limiting energy propagation to one direction. The RADAR signals are transmitted via waveguides, which are transmission lines.
- **Antenna:** In radio engineering, an antenna or aerial is the interface between radio waves propagating through space and electric currents moving in metal conductors, used with a transmitter or receiver. A parabolic reflector, planar arrays, or electronically steered phased arrays may all be used as antennas.
- **Duplexer:** A duplexer is an electronic system that enables bi-directional (duplex) communication along a single transmission line. It separates the receiver and transmitter in radar and radio communications systems thus allowing them to share an antenna. The antenna may be used as a transmitter or a receiver with the aid of a duplexer. It may be a gaseous system that causes a short circuit at the receiver's input when the transmitter is turned on.
- **Receiver:** An antenna is wired to a radio receiver, and it transforms some of the energy from the incoming radio wave into a tiny radio frequency AC voltage that is applied to the receiver's input. An antenna is usually made up of a series of metal conductors. It may be a superheterodyne receiver or some other receiver with a processor to process and detect the signal.
- **Threshold Decision:** To detect the presence of any item, the receiver's performance is compared to a threshold. The existence of noise is considered if the output falls below some threshold.

C. ANTENNA DESIGN

The antenna is designed for radar application; it is determined by the intended application and is constrained by the object to be defined, its size, and position. If the application needs a longer range, the antenna's directivity would be more important. There are other factors to consider when selecting an antenna, such as manufacturing costs, antenna dimensions, gain, and efficiency.To increase gain and directivity, we constructed an multi-antenna with four radiating sources in this paper.

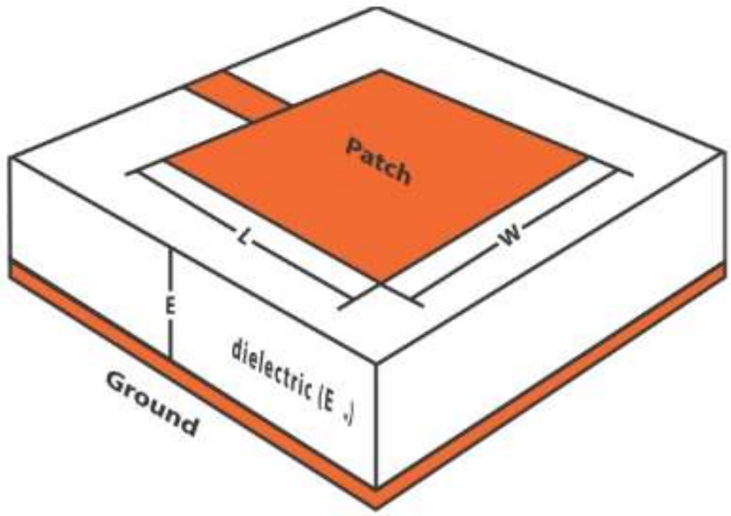

Fig: 1 Antenna design

Single patch antenna design

The substrate used in the design of RFID systems makes the antenna more effective and useful in the field. To minimise energy losses, a FR4 substrate with a dielectric permittivity of 4.6, a height of 1.6mm, and a tangential loss of 0.018 was used. The antenna's resonance frequency is 9.6GHz.The configuration of a microstrip patch antenna in ADS program is shown in Fig. 2.

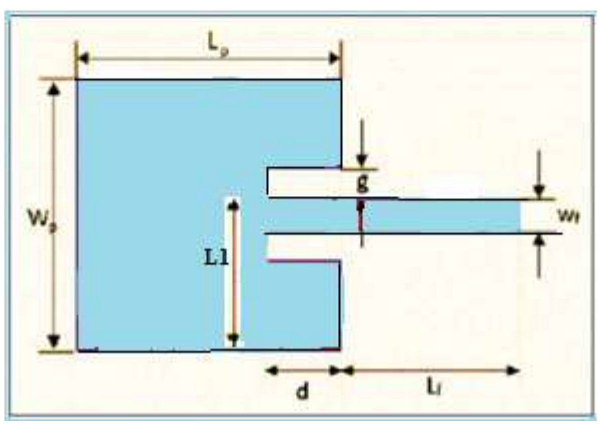

Figure 2.Microstrip patch antenna

Calculations of antenna parameters

1. Formal for the Width (W) of the patch,

$$W = \frac{c}{2f_o\sqrt{\frac{(\varepsilon_r + 1)}{2}}}$$

2. Formula for the Effective Dielectric Constant of the patch,

$$\varepsilon_{eff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\frac{h}{W}\right]^{-\frac{1}{2}}$$

3. Formula for Effective length of the patch,

$$L_{eff} = \frac{c}{2f_o\sqrt{\varepsilon_{eff}}}$$

4. Formula for the length ΔL

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

5. Formula for actual length of the patch

$$L = L_{eff} - 2\Delta L$$

PARAMETER	DIMENSION
Width of the patch Wpa	28.5
Width bottom stub Wsb	0.8
Width feeding Wp	5.0
Length of the patch Lpa	9.6
Length bottom stub Lsb	2.5
Length feeding Lp	7.0

Table:1 Parameters of antenna design

Parameters used for design,

- εr = Dielectric constant
- H = Height of the substrate

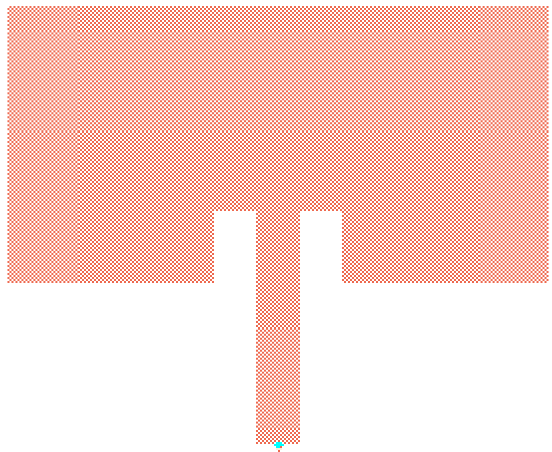

Figure 3. Microstrip patch antenna in ADS

Patch multi-antenna design

Micro-strip patch multi-antennas are made up of a number of patches that operate together to transmit and receive radio waves over greater distances than a single antenna. Multi-antenna architecture aims to increase gain and directivity. As a result, we used the patch antenna with the dimensions mentioned in table 1 to build a multi-antenna with four radiating components.

The feeding network divides the input signal from a SMA connector into four output patches in the planned multi-antenna. A 70-volt /4 transformers is seen to match between a 100-volt impedance line and a 50-volt feeding line. To keep the patches from rubbing together, the coupling between the patches has been used to prevent patch separation, which can eventually affect the gain output of the patch multi-antenna. The aim of designing a patch multi-antenna is to achieve the best possible parameters, such as return loss, gain, and directivity. Figure 3 depicts the multi-antenna's optimized architecture under ADS.

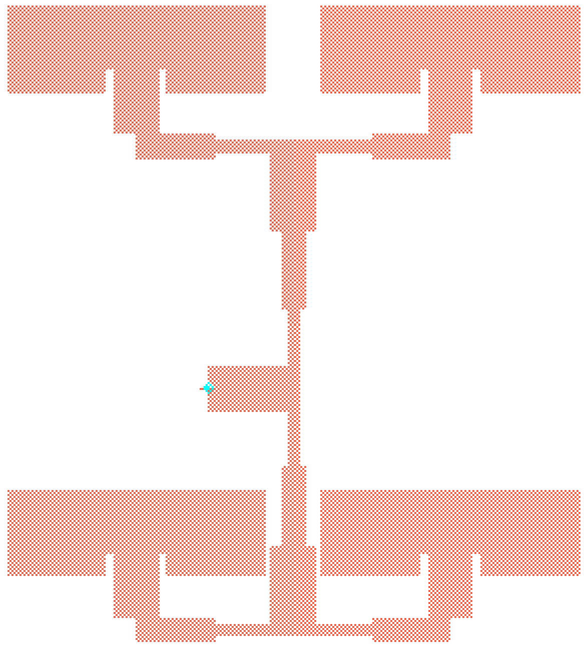

Figure 5. Optimized design of multi-antenna in ADS

Results

The simulation results for the microstrip patch antenna (2.4GHz) and microstrip multi-antenna are presented in this section. Advanced Design System (ADS) software was used to design and simulate the antenna. Benefit, directivity, and reflection losses are the parameters that are recognized.The return loss of the multi-antennas is shown in dB in the diagram above. Any operation should have a return loss of less than -10 dB. At 9.6GHz, the 2x2 multi-antenna has a lower return loss value of S_{11} = -4.487dB, shown in figure 5.The results show that the multi-antenna arrangement effectively increases the patch's gain and directivity, making the design ideal for use in the X band.However, the most important aspect of the project is the development of an multi-antenna for an RFID reader to increase gain and directivity for long-range applications such as vehicle identification.

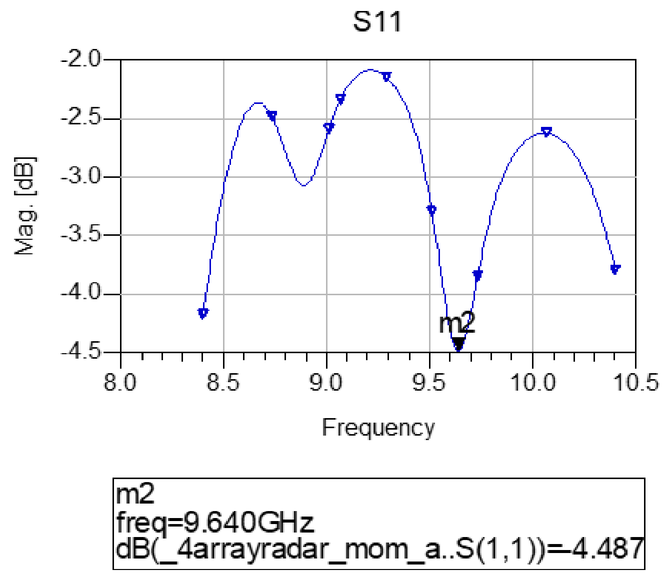

Figure 5. Simulated reflection coefficient (in dB) of multi-antenna (9.6 GHz)

The radiation pattern of the microstrip patch multi-antenna is determined in Figure 6. Using far-field, the result was 9.640 GHz. Since the combination of multiple radiating elements added where it is possible to increase the gain and hence the directivity, this radiation pattern is more effective and directive.

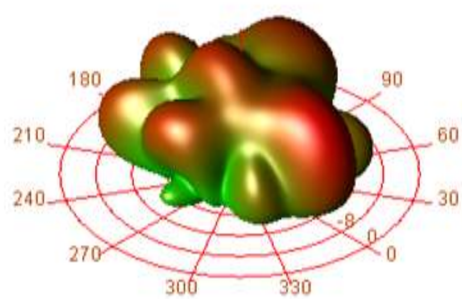

Figure 6 Radiation pattern of multi-antenna

Conclusion

Using ADS simulation software, multi-antenna for 9.6GHz is proposed in this paper. The proposed design is a basic framework that can be created at a low cost.The multi-antenna's gain was calibrated to be 18.453 dB in each case. The use of a four-patched multi-antenna improves the radiation efficiency substantially, according to simulation results.When a single patch is used, the antenna's directivity and gain are average, however as the number of patches combined in the multi-antenna grows, the directivity and gain increase with time, and reflective losses are reduced. As a result, the antenna's output is directly influenced by the number of radiating elements in the array as well as the feeding process. The results show that a microstrip multi-antenna for 9.6 GHz is a viable option for radar applications.

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