Design and Simulation of 4*8 Microstrip Patch Array Design and 8*8 Microstrip Patch Array Design for SART Applications

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Abstract - *To search for the lost ship and aircraft a novel and life-saving instrument called Search and Rescue Transponder is in use globally. The transponder antenna resonates at the frequency of 9 GHz. The design is considered using FR4 (Flame Retardant) substrate of dielectric constant 4.4 and loss tangent 0.0019. A micro strip line fed rectangular patch antenna is designed in such a way that it resonates at 9 GHz. The return loss and gain for the designs are, 4*8 Array Design: Return Loss is -15.0509 dB, Gain Total is 13.471 dB, Gain at 9 GHz is 13.2684 dB; 8*8 Array Design: Return Loss is -28.6635 dB, Gain Total is 15.344 dB, Gain at 9 GHz is 15.344 dB. Other antenna parameters such as VSWR, Radiation Efficiency, Specific Absorption Rate are observed. This design is structured from single design and other designs are carried out accordingly. The design can be embedded in Search and Rescue Transponder Transmitter or it can be attached as an external dock to the transponder. The simulation and analysis were done using High Frequency Structure Simulator (HFSS).*

Key Words*: Microstrip Patch Antenna, Antenna Gain, High Frequency Structure Simulator, Specific Absorption Rate, Radiation Efficiency, *Search and Rescue Transponder*, *Aeronautical Radio Navigation Systems

1. INTRODUCTION

Aeronautical radio navigation service (ARNS) according to the International Telecommunication Union's Radio Regulations is defined as 'A radio navigation service intended for the benefit and for the safe operation of aircraft'. The service is called as safety-of-life service which must be protected for interferences and is one of the essential parts of navigation. A search and rescue transponder (SART) are a waterproof transponder and self-contained which is intended to use at sea for emergency purposes. The radar-SART is used to locate a lost ship/aircraft, survival craft or distressed vessel by creating a series of dots on a rescuing ship's radar screen display.

The Search and Rescue Transponder (SART) will respond to only 9 GHz. The primary use of the SART is to allow rescue vessels or aircraft equipped with X-band radar which is usually used as common marine navigational radar, to home in on the precise and exact position of the SART by enhancing the radar return so that it is clearly visible on the radar of any vessel including search and rescue vessels.

The different bands for various applications under Ultra-wide band is designed using heptagon and nonagon ring like structure in [1]. The dynamic conditions that should be met by a SART antenna and international requirements are reported in [2]. The investigation on Ka-Band for SART for analyzing the potential use of commercial off-the-shelf satellite capacity for real-time teleoperation scenarios over a geostationary relay network [3]. The performance analysis of uniquely designed wideband hexagonal patch antenna having partial ground plane technique is implemented in [4]. A reconfigurable antenna design is implemented using a self-structuring wearable antenna for the local user terminal is considered in [5]. The microstrip patch antenna which is circularly polarized is designed for wide bandwidth used for X-band applications [6].

2. ANTENNA STRUCTURE DESIGN

The antenna design was carried out in such a way that the resonating frequency should be at 9 GHz. Two different slots are considered. One slot cut exactly at half of the entire patch and other a hexagonal shape of radius 2mm slot cut in the first half of the patch. An antenna array design is considered to obtain better antenna properties such as Higher Gain Total, Better Radiation Efficiency etc., The wavelength of the antenna is $\lambda_0 = 33.3$ mm and the antenna spacing should be between $\lambda_0 / 2$(16.65 mm) to $3\lambda_0 / 4$(24.975 mm). The necessary parametric optimization is considered to obtain practically reliable values after simulation. All elements in the array network are spaced effectively to avoid mutual coupling effect which results in decrease in the efficiency of the antenna.

The design specifications for the 4*8 Array Design and 8*8 Array Design are given in Table -1.

Table -1: Specifications for 4*8 Design and 8*8 Design

Design / Parameters	4*8 Array Design	8*8 Array Design
Length of the Patch	99 mm	220 mm

Width of the Patch	253 mm	253 mm
Di-electric Constant	4.4	4.4
Height of the Substrate	1.6 mm	1.6 mm
Resonating Frequency	9 GHz	9 GHz
Slot Width	0.5 mm	0.5 mm
Hexagon Slot Radius	2 mm	2 mm
Antenna Spacing	19 mm	19 mm
Characteristic Impedance	50 Ω	50 Ω

The design of 4*8 Array Design and 8*8 Array Design is designed and simulated using HFSS Software. The designs are seen in Fig -1 and Fig -2 respectively.

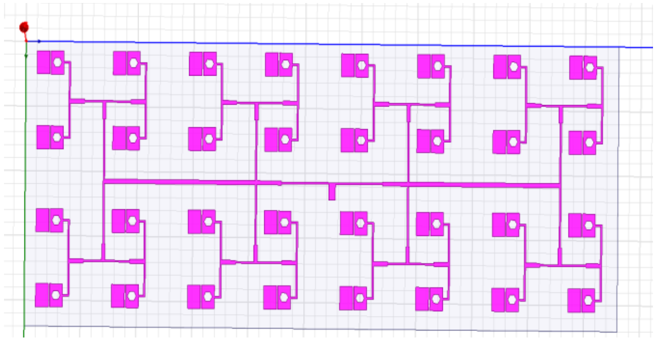

Fig -1: 4*8 Array Design

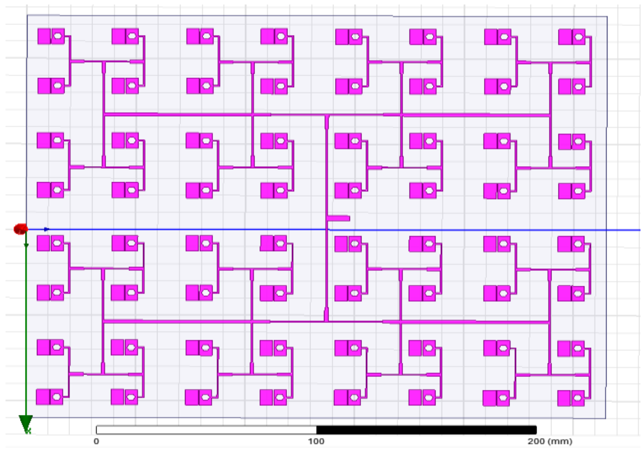

Fig -2: 8*8 Array Design

3. RESULTS AND DISCUSSIONS

The return loss, gain total and gain 2D for both designs are tabulated in Table -2.

Table -2: Antenna Results v/s Design

Design / Parameters	4*8 Array Design	8*8 Array Design
Return Loss(S11)	-15.0509 dB @ 9GHz	-24.6635 dB @ 9GHz
Gain Total	13.471 dB	15.344 dB
VSWR	1.4295 @ 9GHz	1.242 @ 9GHz
Terminal Impedance	50 Ω	50 Ω
Radiation Efficiency	93.25% or 0.9325 @9GHz	90.94% or 0.9094 @9GHz

The 4*8 array design has yielded the return loss of 15.0509 dB at 9 GHz. The Gain Total of the this design is found to be 13.471 dB. The port impedance is normalized to 50 Ω. The Return Loss and Gain Total for 4*8 Array Design can be found in Fig -3 and Fig -4 respectively.

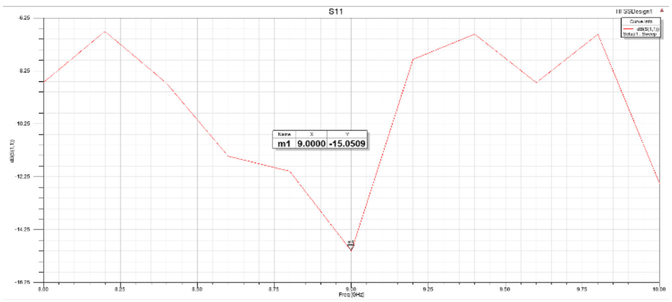

Fig -3: Return Loss for 4*8 Array Design

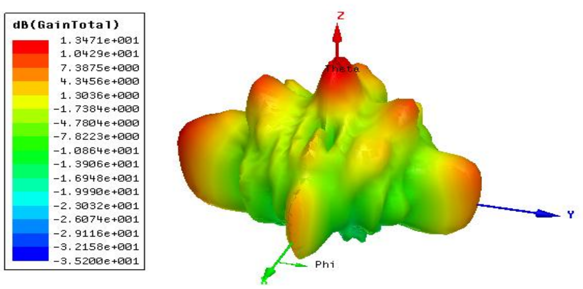

Fig -4: Gain Total for 4*8 Array Design

Radiation efficiency is one of the important parameter to describe how efficiently an antenna transmits and receives RF signals, which is defined as the ratio of the total power radiated by an antenna to the total input power received.The radiation efficiency for single element design is found to be 0.9325 or 93.25% at 9 GHz. The plot for radiation efficiency versus frequency can be seen in Fig -5.

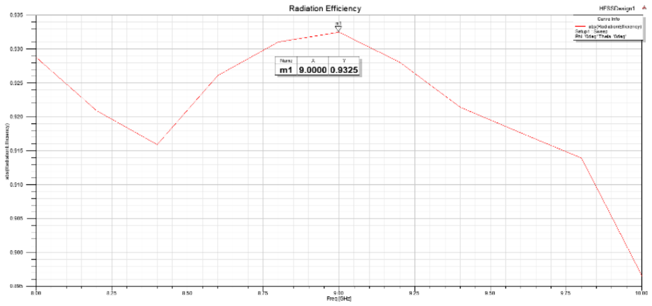

Fig -5: Radiation Efficiency v/s Freq for 4*8 Array Design

The Gain 2D plot denotes the gain for every frequency calculated in the designated range. This design's Gain v/s Frequency plot for 4*8 Array Design as seen in Fig -6 is calculated from 8 GHz to 10 GHz. Necessary optimization techniques can be considered to obtain highest gain at the resonant frequency. The Gain at 9 GHz is 13.2684 dB.

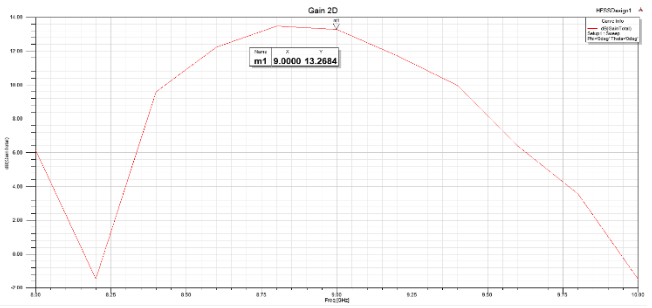

Fig -6: 2D plot of Gain v/s Frequency for 4*8 Array Design

The return loss for 8*8 Array design is found to be -28.6635 dB at 9 GHz. The Gain Total of the this design is increased to 15.344 dB. The port impedance is normalized to 50 Ω. The Return Loss and Gain Total for 8*8 Array Design is seen in Fig -7 and Fig -8 respectively. The Gain Total greater than 15 dB indicates that this antenna can be used for SART applications.

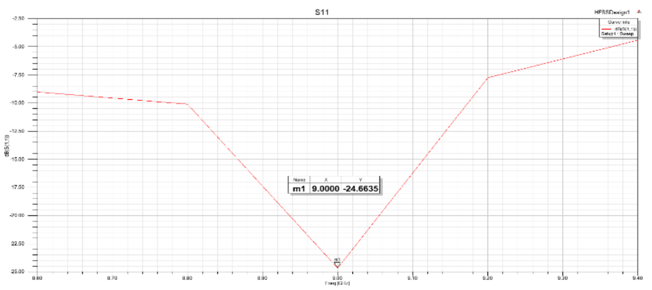

Fig -7: Return Loss of 8*8 Array Design

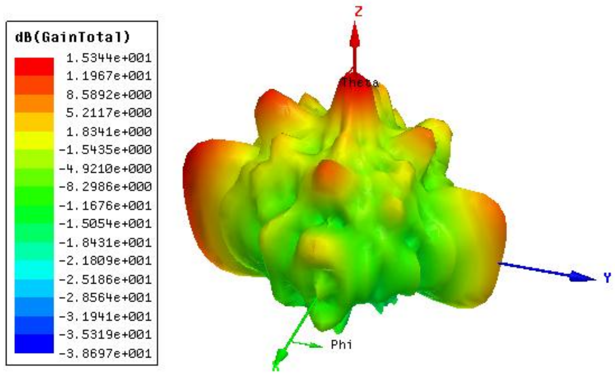

Fig -8: Gain Total of 8*8 Array Design

The radiation efficiency for SART application should be higher and for array designs due to mutual coupling the efficiency decreases. The radiation efficiency for 8*8 Array Design is found to be 0.9094 or 90.94% @ 9 GHz. The plot for radiation efficiency versus frequency can be seen in Fig -9.

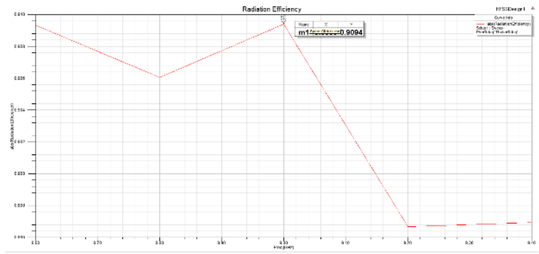

Fig -9: Radiation Efficiency v/s Freq for 8*8 Array Design

The 2D plot of Gain v/s Frequency for the 8*8 Array Design can be seen at Fig.10 and the Gain at 9 GHz is 15.3443 dB. The highest simulation time is consumed by this plot when compared to other plots.

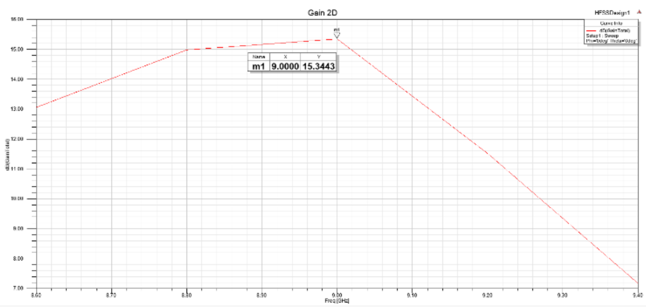

Fig -10: Gain v/s Frequency plot for 8*8 Array Design

4. CONCLUSIONS

The Search and Rescue Transponders is one of the important applications used to detect the lost aircrafts or naval machines. The antenna used which can be used in

SART is designed here using economically feasible Microstrip Patch Antenna considering FR4 Substrate.

The results obtained by the design also depicts that the SART can use any of the above designed antennas for different applications thereby reducing the cost and allowing the common public too to use SART for detection of untracked unmanned aerial vehicles.

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BIOGRAPHIES

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