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PARAMETRIC STUDY OF MICRO STRIP ANTENNA

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ABSTRACT

There are several types of antennas are available in practice but micro strip antennas have more advantages like low-profile, conformable to planar and non-planar surfaces, simple and inexpensive to fabricate using modern printed circuit technology, mechanically robust when mounted on rigid surfaces, compatible with MMIC designs and very versatile in terms of resonant frequency, polarization pattern and impedance. So, by varying different parameters of MAC observe change in bandwidth, gain, resonant frequency etc. Thus, several advantages of MSAs led to the design of several configurations for various applications.

Keywords: *efficiency, gain, metallic patch, micro-strip antenna, resonant frequency.*

I. INTRODUCTION

There has been a tremendous growth in wireless communication in recent years. Today wireless systems find application in almost every area such as satellite communication, mobile communications, radio-frequency identification, local multipoint distribution systems, global positioning system, satellite digital audio radio service, wireless local area networks (WLAN), wireless personal area networks (WPAN), remote sensing, etc. Regardless of the application, such systems demand increased functionality, better performance, reduced size and most importantly lower development cost.

The antenna was born when the existence of electromagnetic waves was first demonstrated by Heinrich Hertz over 113 years ago. Since then, many simple but efficient antennas were invented to support the growth of radio-frequency technology. Antennas are the fundamental component of any wireless communication system. The ubiquity of wireless communications has spurred the development of an extraordinary range of antennas of different shapes and sizes suited for different applications, each with its own advantages and limitations.

When optical fiber communication was growing at a rapid pace in 1980s, the efforts for the further developments of antenna and microwave innovations was discouraged. The success in the advancement of the second generation (2G) mobile phones in the early 1990s changed the entire landscape of the telecommunication industry. There are several types of antennas being used for various applications, each antenna has its advantages and disadvantages [1-8].

Wire Antenna, linear or curved, are some of the oldest, simplest, cheapest, and in many cases the most versatile for many applications. The numerical models for wire antennas are much simpler than plate (2D) or aperture (3D) antenna models. Therefore, even large wire antenna structures can be simulated in a matter of seconds or minutes on an ordinary PC. Wires are often used to model simple linearly polarized antennas like monopoles and dipoles placed on large platforms, Wires are also used to build a circularly polarized helix antenna.

The Loop antenna is another simple, versatile, inexpensive type of wire antenna. The loop antennas can be formed by bending the wire, depending on the shape formed by bending a wire, Loop antennas are classified as a rectangle, square, triangle, ellipse, circular loop antenna etc., because of the simplicity in analysis and construction, the circular and rectangular loop antennas are most popular and has received the widest attention. Therefore, wire antenna's can be 1D or 2D, based on the shape of the wire antenna. The small loop antennas, are also known as a magnetic loop, generally has a circumference, less than one tenth of a wavelength, in which the current distribution on the loop is relatively constant. Therefore, Small loops have a poor efficiency and are mainly used as receiving antennas at low frequencies, except for car radios, almost every AM broadcast receiver sold has such an antenna built inside it or directly attached to it. These antennas are also used for radio direction finding. In amateur radio, loop antennas are often used for low profile operating where larger antennas would be inconvenient, unsightly, or banned. Loop antennas are relatively easy to build [3- 8].

A horn antenna or microwave horn is an antenna that consists of a flaring metal waveguide shaped like a horn to direct radio waves in a beam. Horns are widely used as antenna at UHF and microwave frequencies, above 300MHz. They are used as feeders (called feed horns) for larger antenna structures such as parabolic antennas, as standard calibration antennas to measure the gain of other antennas, and as directive antennas for such devices as radar guns, automatic door openers, and microwave radiometers. Their advantages are moderate directivity, low standing wave ratio (SWR), broad bandwidth, and simple construction and adjustment. The horn is widely used as a feed element for large radio astronomy, satellite tracking, and communication dishes found installed throughout the world. In addition to its utility as a feed for reflector and lenses, it is a common element of phased arrays and serves as universal standard for calibration and gain measurement of other high gain antennas [3-5].

Subsequent demands of reflectors for use in radio astronomy, microwave communication, satellite tracking resulted in spectral progress in the development of sophisticated analytical and experimental techniques in shaping the reflector surface and optimizing illumination over their aperture to maximize the gain [1-2]. The Horn and Aperture antennas are the type of 3D antennas. Of the great variety of antenna systems, planar antennas have gained wide popularity due to the ever-growing trend toward system integration and miniaturization. Planar antennas offer the advantages of low profile, small size, light weight, easy fabrication, low cost, and easy integration with the rest of the electronics, to name a few. [1-2].

Micro-strip antenna in its simplest form consists of a metallic (radiating) patch on one side of a dielectric substrate and a ground plane on the other side. The metallic patch can take different configurations. However, the rectangular and circular patches are most popular because of ease of analysis and fabrication, and their attractive radiation characteristics, especially low cross polarization radiation. Micro-strip antenna performance is affected by the patch geometry, substrate properties and feed techniques [7-8].

High Gain antennas are realized by line fed antenna arrays or reflect-arrays. Line-fed micro-strip antenna arrays are planar but have the disadvantages of low efficiency due to line losses and higher cross-polar radiation due to the feed-line network. Reflect-array antennas have been proposed [1-3]. Reflect-arrays avoid the feed-line network and can be made flat or conformal. The feed antenna of the reflect-array is located in its radiation aperture which results into aperture blockage. Also, the design of the reflect-array is highly involved and its efficiency is low due to dielectric losses.

Micro strip antenna (MSA) offers many attractive features such as light weight, small size, low profile, ease of fabrication, ease of integration with microwave integrated circuits (MMICs) and a planar structure that can be made conformal to host surface and therefore most popular and widely used. However, MSA suffers from low directivity, narrow bandwidth, low efficiency and low power handling capability [1-5]. Several bandwidth enhancement techniques of MSA have been proposed [7-8].

To avoid the plaintext attack, the analysis has done on security of orthogonal blinding schemes that disturb an eavesdropper’s signal using artificial noise transmission [6]. In wireless communication MIMO techniques is evolving technology that offers considerable increase in data bandwidth without any extra power transmission. The 5G has many merits over 4G such as non-bulky in space, directive antennas, and coherent angle spread of propagation [5]. To overcome the low directivity of MSA, high directivity planar antenna structures for long-range wireless links have been proposed from time to time [6]. Antenna size, weight, cost, antenna efficiency, cross polarization and front to back lobe ratio are some of the parameters which govern the performance of a directive antenna.

II. MICRO STRIP ANTENNA

Micro strip antennas became very popular in the 1970s primarily for space borne applications. These antennas consist of a metallic patch, dielectric substrate and a ground plane. The metallic patch can take different configurations such as square, rectangular, circular, triangular, ring, etc. However, the rectangular and circular patches are the most popular because of ease of analysis and fabrication, and their attractive radiation characteristics, especially low cross polarization radiation. The Fig. 3.1 shown below is the structure of the micro strip patch antenna.

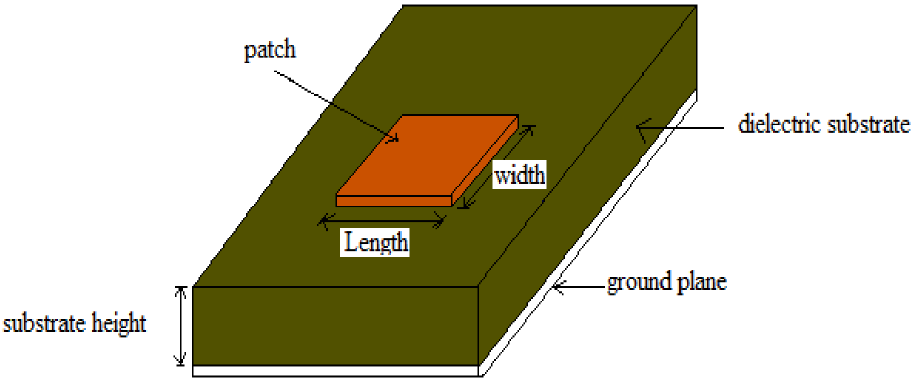


Fig. 3.0 Structure of Single Micro strip Antenna

The MSA structure is designed with 0.5mm thickness of ground plane and FR4 substrate is placed above the ground keeping 1mm air gap between them. The structure is optimized to operate over 5.725- 6.4 GHz, ISM band and satellite C band. Feed patch is fed through a coaxial probe of 50 Ω. To achieve high efficiency, air is used as a dielectric medium between feed patch and ground plane. The structures are simulated using IE3D 12.0, Zeland software. Simulation time depends on the structural dimension, discontinuity between metallic patch and dielectric, dielectric permittivity, number of meshed cells, frequency steps and highest frequency.

1.1 Effect of change in RIS Square patch size

The suspended MSA with RIS is optimized and its dimensions are MSA patch of 12.8 mm x14.5 mm, feed position at 4.7 mm along width edges on x axis, ground plane of 38 mm x 38 mm and a Reactive Impedance Surface of 5x5 square patches of size and spacing 4mm. The optimized antenna structure provides, an impedance bandwidth of 679 MHz, maximum efficiency up to 73.5%, cross polar level -17.1 dBi, F/B lobe ratio of 15.7 dB with no side lobes and 7 dBi gain with variation less than 1 dB over 5.7 to 6.4 GHz. The change in RIS square patch size changes the resonant frequency of the antenna, with increase in RIS square patch size the impedance becomes more inductive and less resistive. Also, with increase in RIS patch size the resonance frequency of the R.L decreases and vice versa. The R.L and impedance variation vs. frequency is shown in “fig 1” (a) and (b) respectively. In these structures, the return loss and bandwidth both degrades either by increasing or decreasing the optimized RIS patch size. The magnitude of the gain, efficiency and its variation over the operating frequency increases slightly with decrease in RIS square patch size as shown in “fig 2” (a) and (b) respectively. The cross polar level and back lobes increases with increase in RIS square size as shown in “fig 3”.

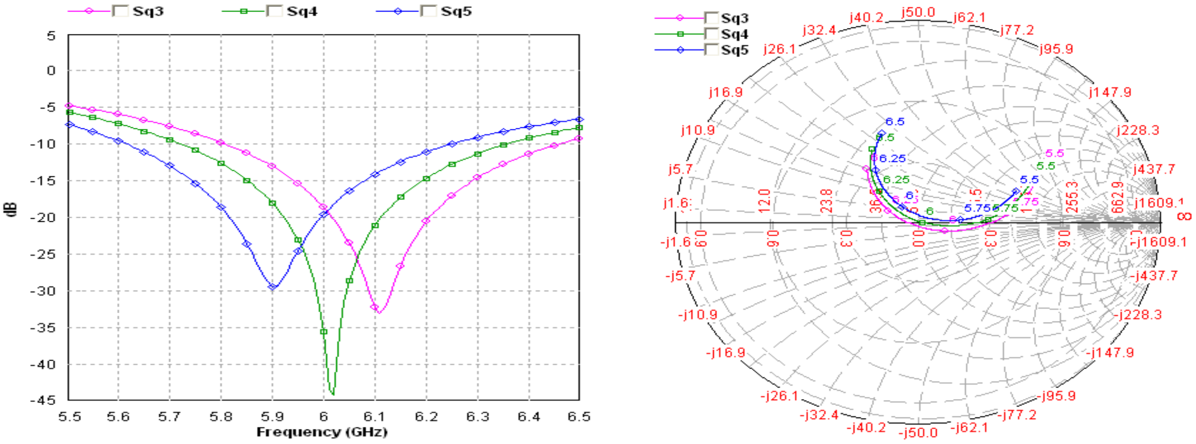


Fig.1 (a) Return Loss vs. Frequency (b) Impedance variation vs. Frequency

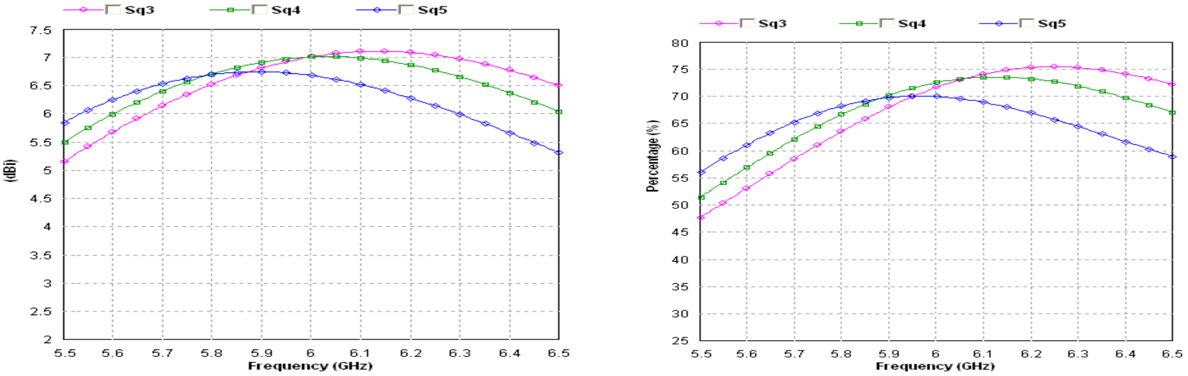
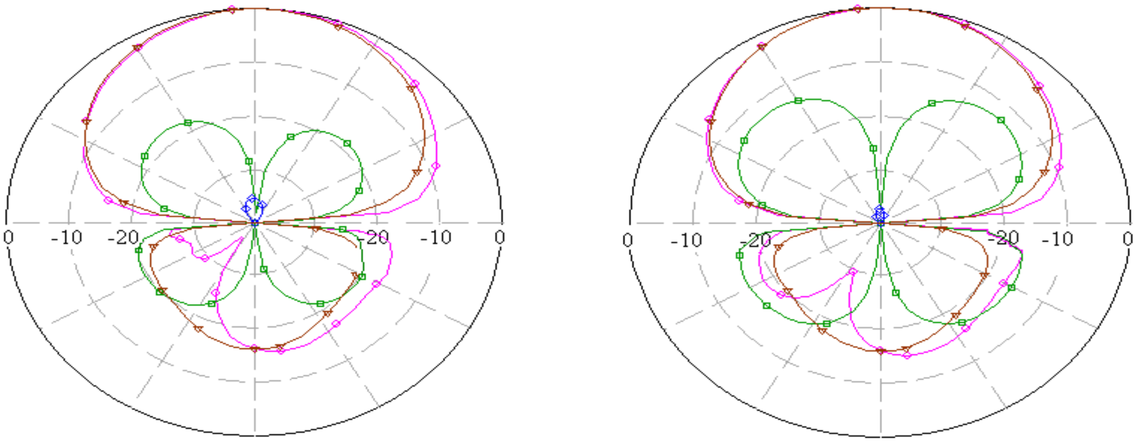
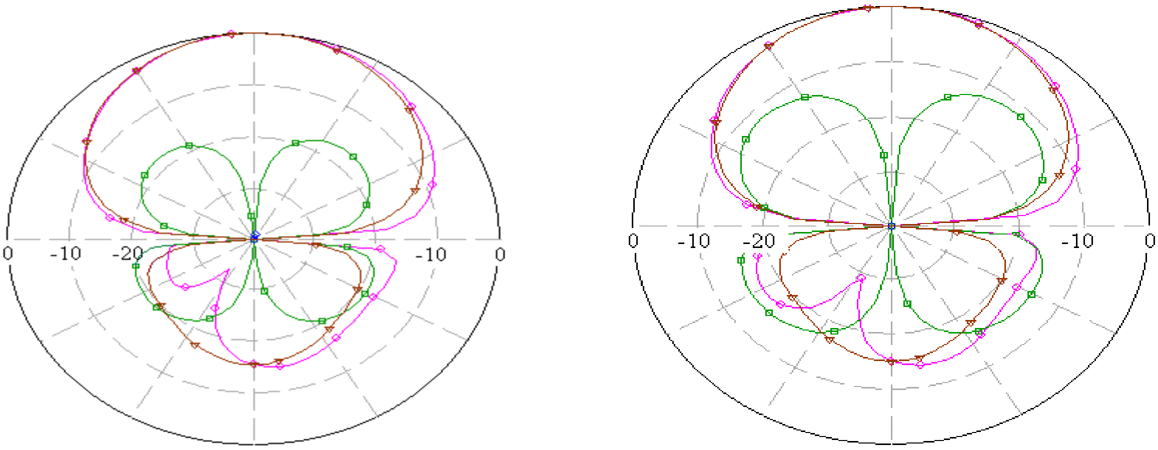


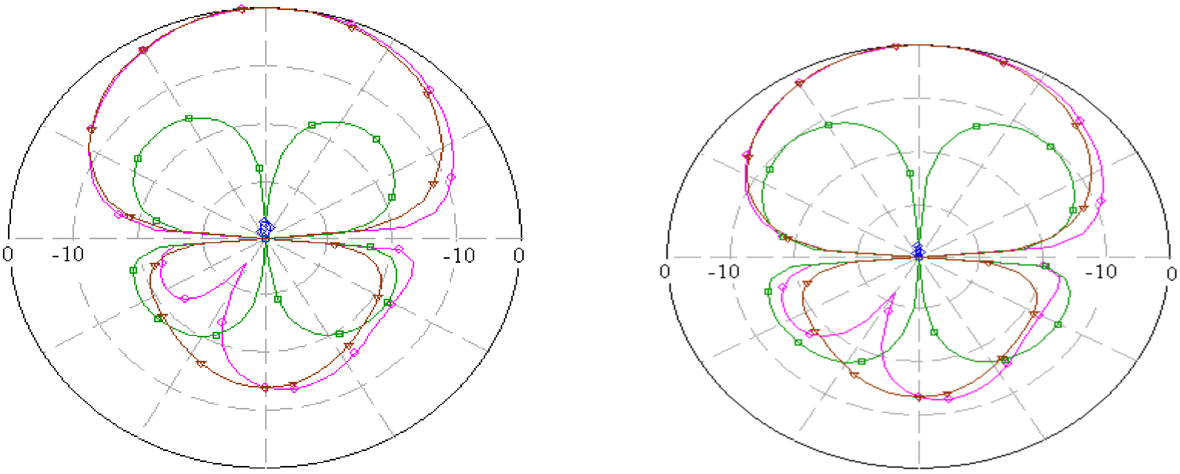
Fig. 2 (a) Gain vs. Frequency (b) Efficiency vs. Frequency



RIS Square size of 3mm



RIS Square- 4mm



RIS Square size of 5mm

(a) 5.8 GHz (b) 6.15 GHz

(—◇— E_θ —▽— E_φ at $\varphi = 0°$ and —□— E_θ —◇— E_φ at $\varphi = 90°$)

Fig 3 Radiation patterns of Suspended MSA with RIS for different RIS square size

1.2 Effect of change in spacing between RIS patch

The optimized suspended MSA with RIS has spacing between RIS patches is 4mm. The change in spacing between RIS patches changes the resonant frequency of the antenna, with decrease in spacing between RIS patches the impedance becomes more capacitive (since capacitance of parallel plates is directly proportional to area of plate, and area increases with decrease in spacing) and slightly less resistive. Also, with decrease in spacing between RIS patches the resonance frequency of the R.L decreases and vice versa. The R.L and impedance variation vs. frequency is shown in “fig 4” (a) and (b) respectively. In these structures, the return loss and bandwidth both degrades by decreasing the optimized RIS patch size. The resonant frequency of the gain and efficiency curve decreases with decrease in spacing between RIS patches. There is no significant change in the magnitudes of gain and efficiency with change in spacing between RIS, as shown in “fig 5” (a) and (b) respectively. The cross polar level and back lobes increases with decrease in spacing between RIS square patches as shown in “fig 6”.

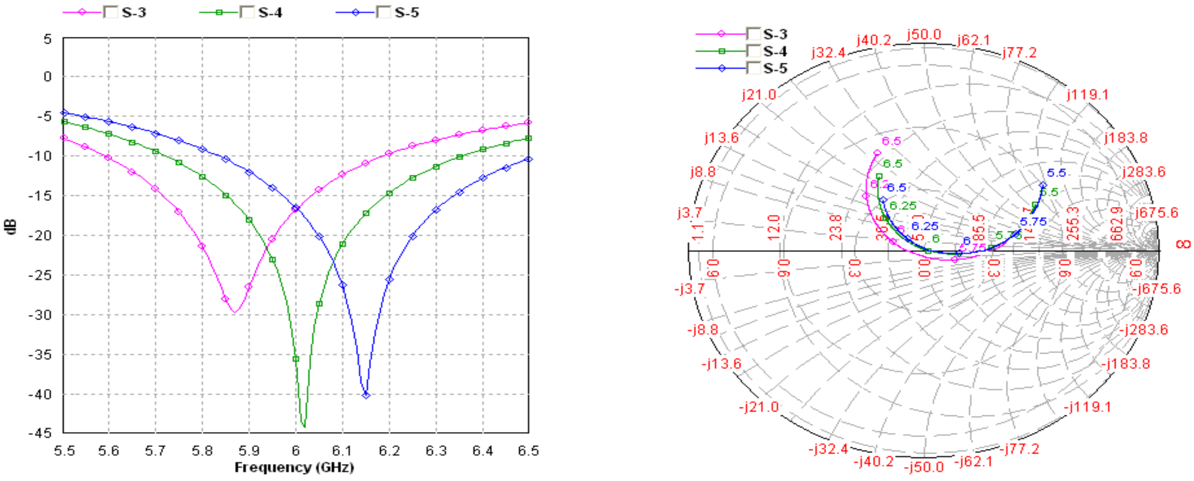


Fig. 4 (a) Return Loss vs. Frequency (b) Impedance variation vs. Frequency

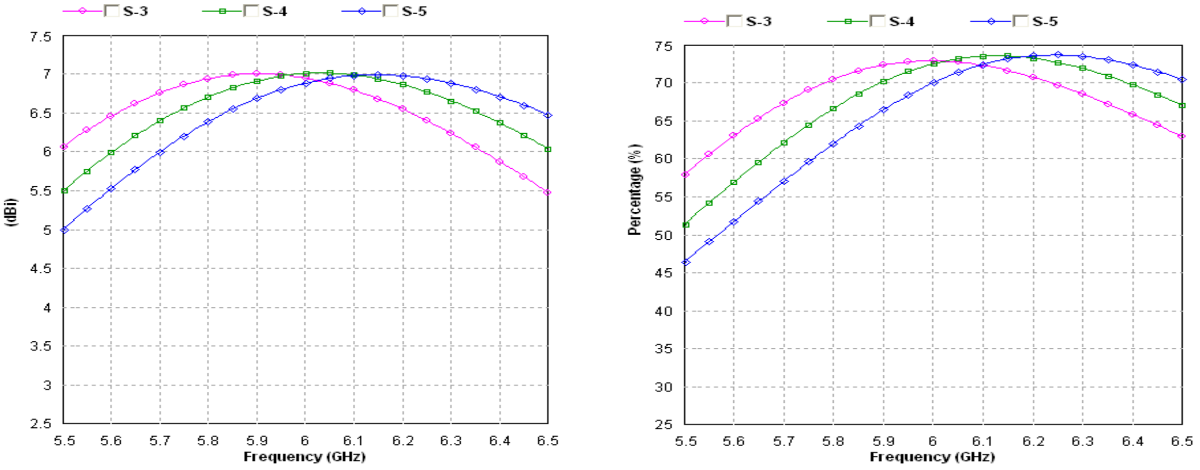
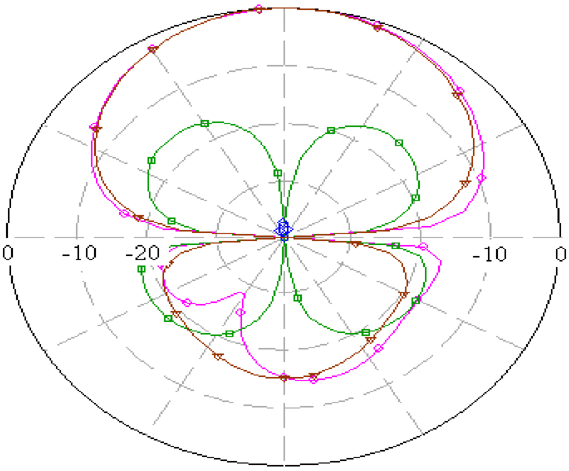
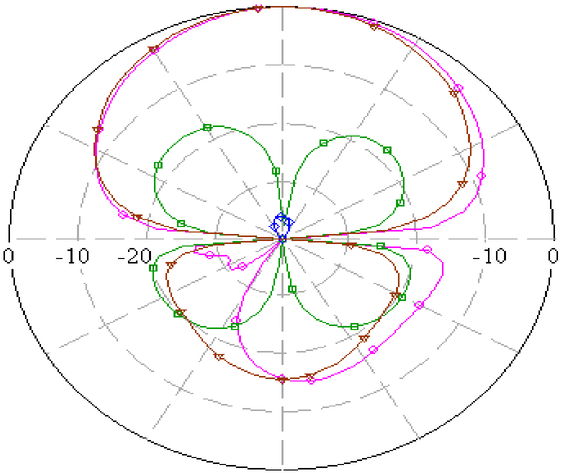


Fig. 5 (a) Gain vs. Frequency (b) Efficiency vs. Frequency



RIS Spacing of 3mm



RIS Spacing of 5mm

(a) 5.8 GHz (b) 6.15 GHz

(—◇— E_θ —▽— E_φ at $\varphi = 0°$ and —□— E_θ —◇— E_φ at $\varphi = 90°$)

Fig. 6 Radiation patterns of Suspended MSA-RIS for different RIS square patch size.

1.3 Effect of Ground plane size

The optimized suspended MSA with RIS has a square ground plane of side 38mm. The change in ground plane dimensions of MSA does not change the resonant frequency of the antenna, with decrease in ground plane size the impedance becomes more capacitive. Also, increasing or decreasing the ground plane size does not change resonant frequency but degrades return loss. The bandwidth of suspended MSA increases slightly with increase in ground plane size and vice versa. The R.L and impedance variation vs. frequency graphs are shown in “fig 7” (a) and (b) respectively. The resonant frequency of the gain and efficiency curve does not change with change in ground plane size, significant improvement in gain and efficiency is observed with increase in ground plane size as shown in “fig 8” (a) and (b) respectively. The cross polar level and back lobes decreases with increase in ground plane size as shown in “fig 9”.

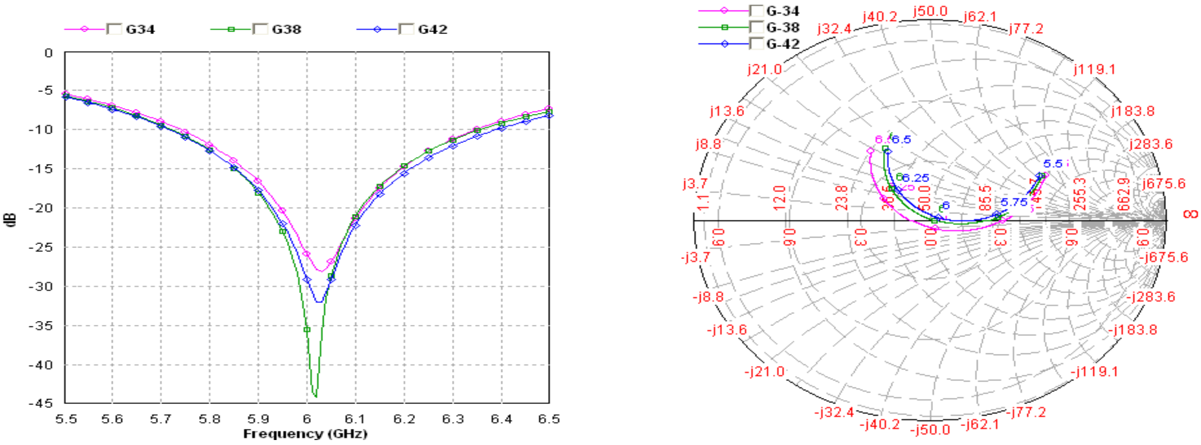


Fig. 7. (a) Return Loss vs. Frequency (b) Impedance variation vs. Frequency

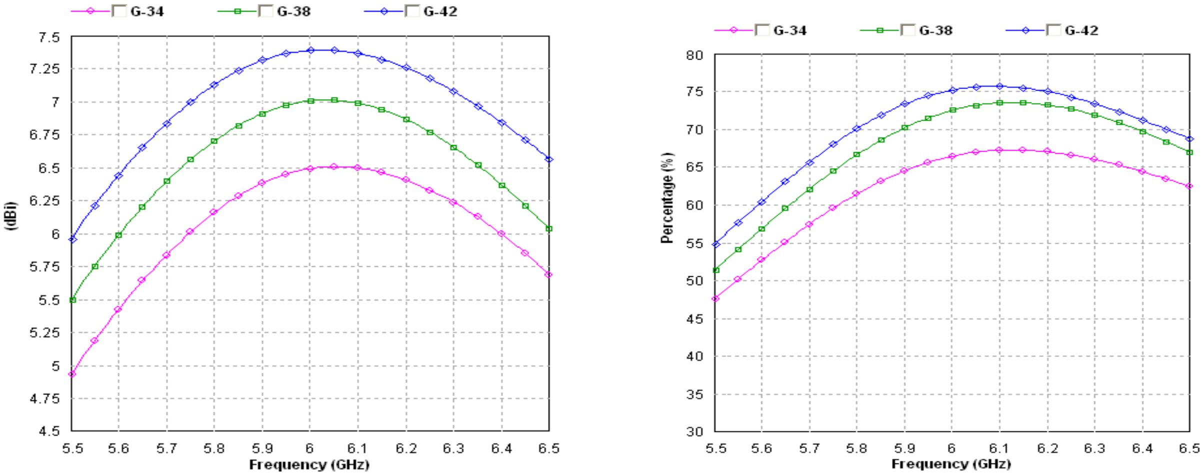
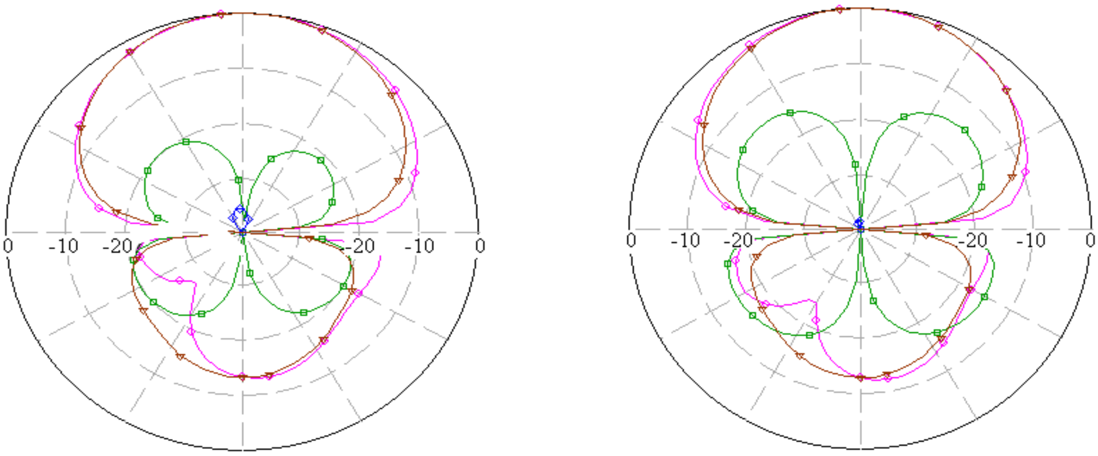


Fig. 8 (a) Gain vs. Frequency (b) Efficiency vs. Frequency



Ground 34

(a) 5.8 GHz (b) 6.15 GHz

(—◇— E_θ —▽— E_φ at $\varphi = 0°$ and —□— E_θ —◇— E_φ at $\varphi = 90°$)

Fig 9. Radiation patterns of Suspended MSA-RIS for different Ground plane size

III. CONCLUSION

The change in RIS square patch size changes the resonant frequency of the antenna, with increase in RIS square patch size the impedance becomes more inductive and less resistive. the return loss and bandwidth both degrades either by increasing or decreasing the optimized RIS patch size. The magnitude of the gain, efficiency and its variation over the operating frequency increases slightly with decrease in RIS square patch size. If decrease in spacing between RIS patches the impedance becomes more capacitive and slightly less resistive. Also, with decrease in spacing between RIS patches the resonance frequency of the R.L decreases and vice versa. There is no significant change in the magnitudes of gain and efficiency with change in spacing between RIS. If decrease in ground plane size the impedance becomes more capacitive. Also, increasing or decreasing the ground plane size does not change resonant frequency but degrades return loss.

REFERENCES

[1] R. D. Javor, X.D. Wu, and K. Chang, “Design and performance of a microstrip reflectarray antenna”, IEEE Trans. Antennas Prop., Vol. AP- 43, pp. 932-939, 1995.

[2] D.M.Pozar, S.D.Targonski and H. Syrigos, “Design of millimeter wave microstrip reflectarrays", IEEE Trans. Antennas Propagat., vol. AP-45 no.2, pp.287-295, Feb. 1997.

[3] D. M. Pozar and D. H. Schaubert, “Microstrip Antennas: The Analysis and Design of Microstrip Antennas and Arrays”, John Wiley and sons Inc. USA, 1995.

[4] Mathias Schulz, A drian Loch and Mathias Hollick “Practical known plaintext attack against physical layer security in wireless MIMO system” Secure mobile networking lab.

[5] Ramya Rajan Choudhary, Assistant professor (ETC), “A network overview of massive MIMO for 5G wireless cellular system model and potentials” Trident academy of technology.

[6] P.N. Chine and Girish Kumar, “Three dimensional, efficient, directive micro strip antenna arrays,” IEEE Int. Symposium Antenna and Propagation, 2005.

[7] Constantine A. Balanis, “Antenna Theory and Design”, 3rdEdition, John wiley ansd sons Inc. USA, 2005

[8] G.Kumar and K.P.Ray, “Broadband Microstrip Antennas”, Norwood, MA Artech House,2003.