International Journal of Engineering and Advanced Technology (IJEAT)
ISSN: 2249-8958 (Online), Volume-12 Issue-3, February 2023

Polarization and Frequency Reconfigurable Antenna using Metasurface: Analysis, Review and Proposal

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Abstract: ***Wireless communication technology experienced drastic developments during the last few decades. Meanwhile the reconfigurable antenna had attracted more researchers because of its growing needs in various applications. Reconfiguration was performed to replace numerous antennas with single reconfigurable antenna which is capable of changing the Frequency, Polarization, Radiation Pattern etc. Antenna reconfigurability is attained by deploying several switching mechanisms among them electronic switching mechanisms are commonly used because of its simple integration, reliability, and efficiency. In this paper, review of various implementation techniques for antenna reconfiguration using metasurface are studied. Some of the reviewed factors are: Metasurface is the distribution of electrically small scatters called two-dimensional metamaterial. Metamaterial is an artificially built periodic array structure which consists of subwavelength cells. Some of the reviewed challenges in reconfiguration of the antenna are modeling of reconfigurable reflectarray, low-profile, high gain, unidirectional radiation pattern etc. Finally, some of the features, parameters and fundamental properties for designing reconfigurable antenna were investigated. Based on the study conducted, reconfigurable structure for 5 G application using metasurface is proposed***

Keywords: ***Polarization, Frequency, Polarization Reconfigurable antenna, Metasurface, Metamaterial***

Nomenclature

θ- rotation Angle
R- Resistance
C- Capacitance
L- Inductance
δ_0 - free space dielectric constant,
δ_S - dielectric constant of the substrate
β_0 - free space magnetic permeability,
$\overrightarrow{E_1}$, $\overrightarrow{E_2}$ - Components of Electric Field
F_{xn},F_{yn} - Component of Electric Field in X and Y direction
φ_{xn}, φ_{yn}- Phase of components in X and Y direction
TM_{20} - Transverse Magnetic Mode

Manuscript received on 31 January 2023 | Revised Manuscript received on 09 February 2023 | Manuscript Accepted on 15 February 2023 | Manuscript published on 28 February 2023.

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I. INTRODUCTION

Antenna plays a vital role in the wireless communication systems. Modern wireless communication systems requires compact antenna with enhanced performance, numerous functionality, higher gain and compact Size [1]. Replacing number of discrete antenna structures by a single compact reconfigurable antenna structure is advantageous in wireless communication systems. Reconfigurable antennas can be broadly classified into 3 major types, Frequency [2, 3], radiation pattern [4], and polarization [5, 6] reconfigurable antennas. Compound or Hybrid Reconfigurable antennas are also common in application where more than one parameter of the antenna can be reconfigured. Reconfiguration of polarization and frequency can be achieved electrically or mechanically [7, 8]. Electrical based reconfiguration is preferred to mechanical based reconfiguration. Earlier use of PIN, varactor diode [26, 27]. and parasitic pixel layer are widely used as elements for reconfiguration. The main disadvantage of these method are use of additional biasing elements and bulk size. Structures like metasurface have been introduced recently using that polarization reconfiguration [9] and frequency reconfiguration [10, 11] can be achieved without the use of additional biasing elements. The metasurface is a surface distribution of electrically small scatters which is also referred to as two-dimensional metamaterial. Recently, metasurface is much popular element in reconfigurable antennas due to its compact design and reduced cost. The use of Metasurface spared the use of Biasing Elements and additional power sources. H.Zhu et.al. [12] proposed a Polarization reconfigurable antenna where metasurface is positioned at top of the main radiating antenna which realizes linear polarization, right hand, and left-hand circular polarization by rotating the metasurface . In [10, 13-17], frequency reconfiguration is introduced where durability is acquired by rotating metasurface which is positioned at top of antenna. [14] analysed a DNG metasurace for wireless LAN application where the metasurface is placed on the top of the patch. Rachedi, K et.al [45] proposed a compact reconfigurable antenna for Green Wireless Communication the antenna is capable of generating up to eight radiation pattern T.

Cai et.al. [18], proposed an X-band quad-beam transmits array which uses an enhanced dual-mode metasurface. Metasurface has attained a full phase circle of 360 degrees. H. X. Xu et.al. [19] proposed a bifunctional metasurface to control radiation beam efficiently. Metasurface are widely used in converters for linear polarization (LP). C. Fang et .al [20] and J. C. Zhao et.al [21] introduced wideband and ultra broadband reflective LP converter with high efficiency. J. Zhao et.al. Sam, W et.al [44] designed and fabricated reconfigurable integrated SIW filter and antenna using varactor diodes, The reconfigurability is achieved through multi layer technique and use of reverse voltage for turning the filter .. [22] proposed an enhanced photo excited switchable broadband reflective LP conversion metasurface for Terahertz (THz) wave. The proposed structure acquires 99% of PCR value for the resonance frequency of 1.42THz, 1.01THz, and 0.69THz. G. Varamini et.al [23] proposed a structure in which metamaterial was overloaded on a microstrip antenna which makes antenna to efficiently acquire dual-band characteristics. G. Varamini et.al [24] presented a microstrip antenna depending on loop formation along with metamaterial load where Circular polarization is achieved by altering the current distribution by changing the position of metasurface. H.-X. Xu et.al [25] proposed a Multifunctional microstrip array using linear polarizer and focusing metasurface. [35], [37]and [38] proposed the metasurface antennas for wideband application using character mode analysis and mainly for satellite application. Alnahwi et.al [41] presents a novel sensing and communicating antenna for CR systems the communicating antenna is designed as a frequency reconfigurable antenna using varator diode attached to the radiating patch. The mutual coupling between the sensing and communicating antenna is lessthan -20dB Shankarappa S. et.al [42] proposed a pattern reconfigurable antenna to develop an intersatellite communication link between flying spacecraft. PIN diodes are used to select Reconfigurable Selective Reflectors (RSR). The antenna resonates at 2.45 GHZ and results shows good impedance matchinf and wide beam width. Ahmed. S et.al [43] studied the introduction of metasurface in filtering antenna the studies concluded that the filtering antenna designed using metasurface is efficient for radar system, medical monitoring and firefighter tracking. In this paper, a survey on polarization and frequency reconfigurable antenna using metasurface was done. Metasurface are created from metamaterial with novel structure for various applications. The structure of the metasurface is selected based on the application and the frequency band. The use of metasurface based antennas have enhanced performance in reconfiguration when compared to conventional reconfiguration mechanisms using PIN diodes and parasitic pixel layers. The use of biasing circuits and additional power wastage can be eliminated by the introduction of metasurface.

II. DESIGN OF POLARIZATION RECONFIGURABLE ANTENNA USING METASURFACE.

Reconfigurable antenna could recognize the function of numerous antennas, which enhances the ability of space utilization and performance of the antenna. Polarization reconfigurable antenna could recognize frequency multiplexing, remove multipath fading in the remote sensing and communication systems. Circular Polarization (CP) antenna has numerous applications in satellite communication like suppressing intervention of fog, rain, better mobility, and repelling multipath reflection. So, a conversion from linear to circular polarization is of growing demand.

Several LP to CP reconfigurable antenna models is currently available. Among them, one of the popular way to recognize CP configurability is by altering current path with PIN diodes in radiating elements [26, 27]. The main disadvantage of this method is the use of additional biasing elements for turning ON and OFF the diodes. Another method utilizes an optimal metasurface, which includes periodic subwavelength structures like rectangular patches with cut off corners and polarization reconfigurability was established mechanically by rotating metasurface on the top of main radiating elements [12, 28, 29] here the use of additional biasing elements can be eliminated . Z. Zhang et.al. [30] introduced a novel technique to recognize CP reconfigurability by using hybrid periodic metasurface (HPM). The antenna was designed with Dual Orthogonal Linear Polarization (DOLP) using periodic metasurface patterns incorporated to main radiating element which is a cross dipole.

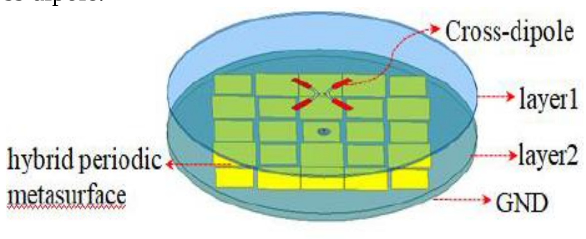

Figure 1 a: Configuration of Antenna According to [30]

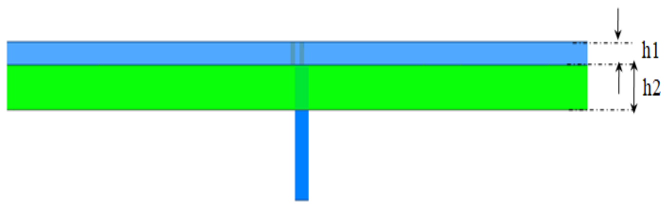

Figure 1 b: Side View [30]

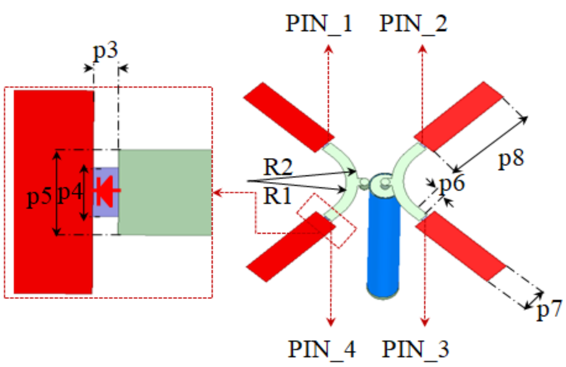

Figure 1 c: Probe Feed and Cross Dipole [30]

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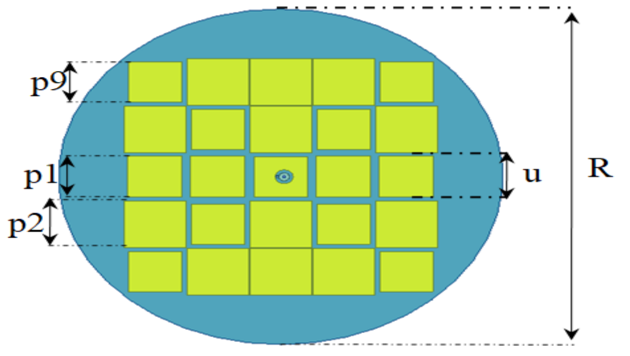

Figure 1 d: Metasurface Pattern [30]

As depicted in Figure 1a, the antenna contains 2 layer substrate. Cross-dipole was overloaded with 4 diodes on the top face of upper layer. HPM consist of 5× 5 patches which are positioned on the top face of the lower grounded layer. 2 layers utilize Rogers 5880 substrate with dielectric constant 2.2 and 1mm and 4mm thickness. Layer radius is 92mm. The antenna is provided with a coaxial probe, with its outer and inner conductor linked with 2 sides of cross dipole. Whereas HPM consist of 3 sets of subwavelengths with u periodic and p9, p2 and p1 patch size. Among them, p1 has the largest patch size, p9 has 45-degree orientation patch size and p2 has 135 degree orientation patch size

Table 1: Dimensions of Antenna (units: mm) According to [30]

Parameter	p8	p7	p6	p5	p4	p3	p2	p1
Value mm	14	3.9	1.5	1.64	0.94	0.3	25.6	22.6
parameter	R		U	R2	R1	h2	h1	p9
Value mm	92		26	7.44	6.8	4	1	22

Polarization reconfigurability was achieved with 4 PIN diodes, overloaded in cross-dipole. Dual orthogonal LP reconfiguration was recognized by cross-dipole by controlling OFF and ON state of the 4 PIN diodes. With the support of HPM, LP was changed to CP radiation, which are outputs of dual CP reconfiguration. The simulation result of this model exhibit -10dB impedance, a bandwidth of 2.45 GHz ~ 3.14 GHz approximately (24.7%), the axial ratio bandwidth is 2.72 GHz ~ 2.92 GHz (7.1%) and 8.54dBi is the realized gain. Chen et.al [31] proposed a model of the antenna as illustrated in Figure 2. It consists of three metallic layers separated by two layers of medium with different dielectric constant. The top layer labeled layer 1 is the metasurface. Between the 1st and 2nd layer, Arlon Di Clad 880 was used with relative permittivity 2.2. 2nd and 3rd layer form slot antenna, media between them was Arlon 25N which has relative permittivity 3.38

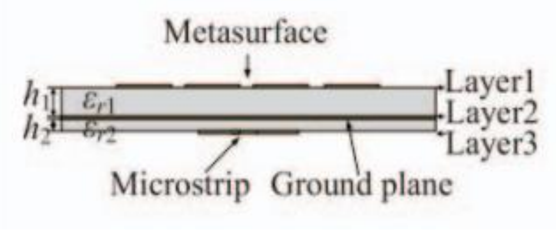

Figure 2: Side View of Antenna with h1 = 1.575 mm and h2 =0.813 mm [31]

Primarily, the top layer was metasurface which was framed by 4*4 nonuniform rectangular metal films. The layer was modeled to enhance the whole antenna's gain and to adjust patterns shape. This layer had PIN diode switches which were utilized to attain pattern reconfiguration. By controlling the ON and OFF mode of switches, the corresponding length of the slot could be controlled and the antenna's corresponding circuit could be altered. So performance was attained with pattern reconfiguration. Switches of PIN diodes were positioned in such a way to attain polarization reconfiguration. Switches were utilized to alter the model of polarization among LHCP and RHCP. The simple and single-fed structure was used within CP switchable antenna. Because of diode non-linear coupling, the antenna had CP radiation. Patch antenna's resonant mode had ±90° phase difference. In this way, circular polarization reconfiguration was attained.

The simulation result expresses that antenna was modeled in a way to switch its direction of polarization and pattern from 4.95 – 5.05 GHz by altering the mode of PIN diode switches. The radiation pattern had 3 directions and the range of scan angle is from -20° to 20°. The direction along the Z-axis could attain polarization reconfiguration among RHCP and LHCP. Result proves that antenna attains 7 to 8 dB gain.

III. FREQUENCY RECONFIGURABLE ANTENNA USING METASURFACE

With the support of electrical mechanisms, frequency reconfiguration was attained by incorporating Varactors, PIN-MEMS, PIN diodes, etc H. Gu et.al [32]. PIN diode is broadly used in frequency reconfiguration. By controlling ON and OFF states of PIN diodes, various frequency bands could be switched. Similarly, Varactors were utilized to tune the frequency band. However, there were few drawbacks with an electrical mechanism for reconfiguring antenna such as i). to drive, Varactor and PIN diodes DC power is used, which creates possible active jamming. ii). Antenna's structure becomes complex due to the DC circuit. Inorder to overcome all the above-said drawbacks, the metasurface antenna was introduced like one proposed by H. Zhu et.al [15], where the antenna reconfiguration was achieved based on the size, structure, position and alignment of metasurface with respect to antenna. There were several advantages with the metasurface antenna like i). compact size, ii). low cost and low profile, iii). high efficiency and gain and iv). no active jamming.

M. Zhu et.al [17] proposed a metasurface antenna which consists of a patch antenna. It was noted that the patch antenna is modeled as a basic metasurface antenna. For the circular motion of antenna, the antenna was modeled as a circular patch antenna with a 40 mm diameter. RO4350B Roger was selected as the dielectric substrate with relative permittivity 3.48 and 1.524 mm thickness. Patch antenna has a double sided substrate, Figure 3a represents patch (upper side), and Figure 3b represents ground (lower side). This patch is in the shape of a rectangle with a width of 12mm and length 18mm.

Retrieval Number:100.1/ijeat.C40310212323
DOI: 10.35940/ijeat.C4031.0212323
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It's delivered directly utilizing coaxial and SMA coaxial connector over substrate and ground to link patch. Simulation result of this model express that 90 degree rotation alters resonant frequency from 4.52 GHz to 5.31 GHz. and attains 1.12GHz reconfigurable bandwidth at around 5GHz.

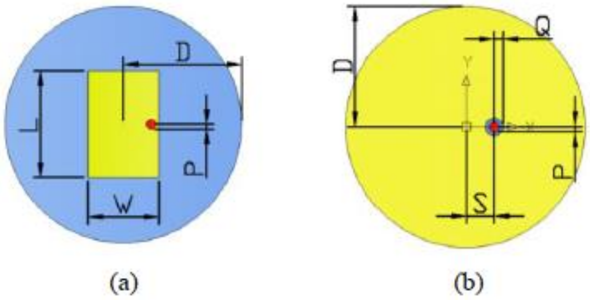

Figure 3: Dimension of Patch Antenna a). Front side b). Back side [17]

Table 2: Patch Antenna's Dimension (unit: mm) [17]

Via radius	1.5
Coaxial radius	0.8
Patch width	12
Patch length	18
Antenna's radius	20

G. Feng et.al [33], proposed a design as depicted in Figure 4. The slot antenna was modeled on one sided FR4_epoxy substrate with 4.4 relative permittivity, loss tangent of 0.02, and 1.5 mm thickness. The antenna was fed with CPW (Coplanar waveguide). Metasurface contains a circular unit cell along with a square hole that was positioned on the substrate's top side. Metasurface's θ rotation angle was computed from the x-axis as illustrated in Figure 4b. Due to the anisotropy of metasurface, the antenna's resonant frequency was reconfigured by altering the rotation angle. Due to symmetry metasurface, highest θ obtained is 45 degrees. In this model, metasurface was positioned with slot antenna, fulfilling low profile and compact structure. Dimension of the antenna is listed in Table 3.

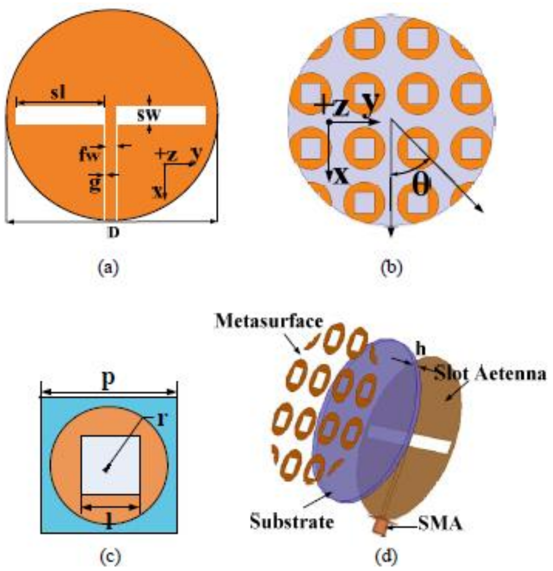

Figure 4 a). Slot antenna, b). Metasurface, c). unit cell, d).Assembly strategy of the antenna [33]

Table 3: Dimensions of Antenna (unit: mm) [33]

h	p	L	R	g	fw	sl	sw	D
1.5	13	5	5	0.1	1.9	22	4	50

By this model, the antenna had a wide range of frequency with 43.2% fractional tunable and 61% of fractional operation bandwidth (2.31 to 4.42 GHz). It is simple to attain frequency tunability by mechanically rotating metasurface. Moreover, this designed antenna had a compact structure and a lower profile with 1.5 mm thickness. The maximum gain attained is 3.5fBi which could be utilized for numerous applications in wireless communication systems like WiMax (3.3 GHz to 3.8 GHz) and WLAN (2.4 GHz to 2.4835 GHz).

IV. POLARIZATION AND FREQUENCY RECONFIGURABLE ANTENNA USING METASURFACE

X. Chen et.al [10] proposed a Frequency and Polarization reconfigurable antenna using PRMS (Polarization Reconfigurable Metasurface) and FRMS (Frequency Reconfigurable Metasurface). PRMS was positioned in the uppermost layer with its unit cell positioned on the side face to the middle layer of FRMS whose unit cell was positioned on the opposite side to patch antenna as illustrated in Figure 5.1. Whole layers were fabricated on the RO4350B substrate, with a thickness of 1.524 mm and dielectric constant 3.48. Figure5.2 and Table 4 represents dimensional representation of PRMS and Figure 5.3 and Table 5 denotes dimensional illustration of FRMS.

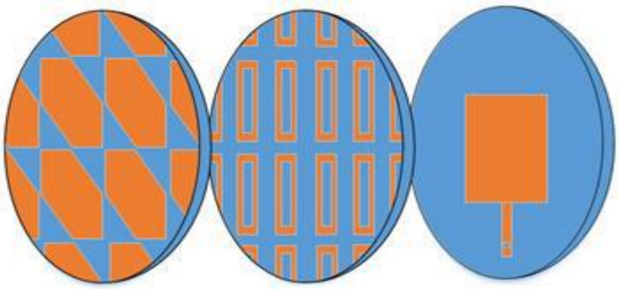

Figure 5.1 Pictorial View of Proposed Antenna [3]

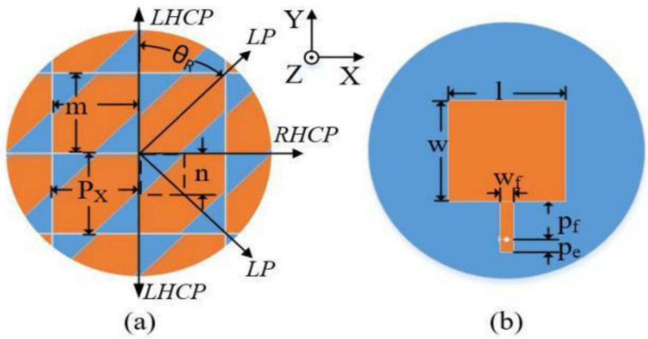

Figure 5.2: a). Structure of PRMS and b). Patch Antenna [3]

The polarization reconfigurability of antenna was attained by rotating PRMS upper layer by θ_S rotation angle. The dimension of PRMS is given in Table 4.

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DOI: 10.35940/ijeat.C4031.0212323
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Table 4: Dimensions of PRMS (units: mm) [3]

p_e	p_f	w_f	l	w	n	m	p_x
2	6	2	17	15.7	6.8	12.9	13.1

Frequency reconfiguration of the antenna was attained by rotating FRMS with θ_F rotation angle w,r,t to y-axis. FRMS's dimensions were illustrated below:

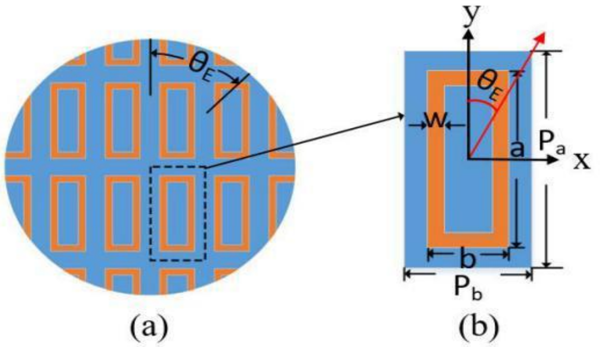

Figure 5. 3: a). FRMS and b). Unit Cell

Table 5: Dimensions of FRMS (units: mm) [3]

w	B	A	pb	pa
1	4.8	11.8	7.5	14.5

M. S. Chen et.al. [11] proposed a polarization conversion metasurface as illustrated in Figure 6a. Part enclosed within the red line is called the unit cell. To characterize the unit cell, magnification was done in Figure 6b. The slot antenna was kept as a source antenna which is Linearely polarized (LP). As illustrated in Figure 6b, the slot antenna was polarized along the X-axis. Placing metasurface on slot antenna, field along X-axis is divided into two orthogonal components. Due to this orthogonal components reconfigurability could be achieved.

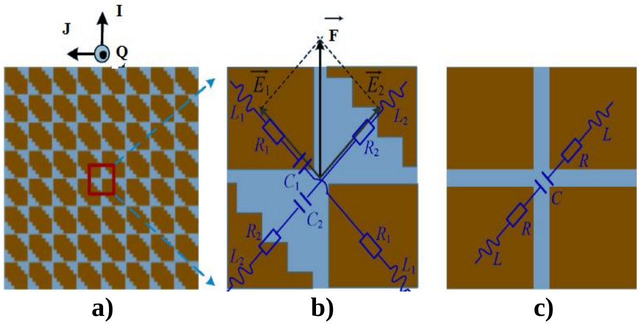

Figure 6: a). Metasur face, b). Unit cell with serrated corners truncated, c). Unit cell with no truncation [11]

As illustrated in Figure 6c, when the unit cell's diagonal corners were not cut into zigzag, then metasurface equivalent circuit was regarded as a symmetrical RLC circuit. Metasurface's imbalance was computed by equation (1)

$$Z = 2R + j\omega\,(2L) = R' + jX' \tag{1}$$

Here R refers to equivalent circuit's resistance, L denotes equivalent circuit's inductance and C refers to distributed capacitance developed by gap among opposite units. As illustrated in Figure 6b, the unit cell's diagonal corners were cut into serration. Varied impedance would be produced by $\overrightarrow{E_2}$ and $\overrightarrow{E_1}$ which were expressed in the below equation:

$$Z_1 = 2R_1 + j\omega(2L_1) + \frac{1}{\omega C_1'} = R_1' + jx_1' \tag{2}$$

$$Z_2 = 2R_2 + j\omega(2L_2) + \frac{1}{\omega C_2'} = R_2' + jx_2' \tag{3}$$

From equation 2 and 3, R_i refers to resistance, L_i denotes inductance and C_i' (where i =1,2) refers to capacitance distributed capacitance for every unit cell. Corner cutting expands the gap among patches and alters the parameter values. C and L were distributed parameters of the equivalent circuit, computed as:

$$C = \delta_0 \delta_s \frac{2\sqrt{2a}}{\pi} \ln \frac{1}{\sin\left(\frac{c\pi}{2\sqrt{2a}}\right)},$$

$$c = \frac{\gamma^2 + 2aq - q^2}{\sqrt{2q}} \tag{4}$$

$$L = \beta_0 \frac{a}{\sqrt{2\mu}} \ln\left(\frac{1}{\sin\left(\frac{k\pi}{2\sqrt{2a}}\right)}\right),$$

$$k = \frac{a - \gamma}{\sqrt{2}} \tag{5}$$

In the above equation, δ_0 denotes free space dielectric constant, β_0 represents free space magnetic permeability, 'c' denotes the relative distance of opposite patches, 'k' refers to the patch diagonal length and δ_S refers to the dielectric constant of the substrate. By equation 5 and 4, the parameter value of C_2 and L_2 could be acquired. When there is an increase in γ the corresponding L_2 increases with a decrease in C_2 . Phase variation among Z_1 and Z_2 could be attained by the various size of truncated corners. When unit cell was truncated such that magnitude of Z_1 and Z_2 are same and phase difference is 90°, then $|E_1| = |E_2|$ and $\angle\overrightarrow{E_2} - \angle\overrightarrow{E_1} = 90°$. The antenna would be RHCP (Right Hand Circular Polarization). When metasurface was rotated to 135° or 45° in counterclockwise direction, the unit cell that was symmetrical with antenna and X-axis the antenna is changed to LP. When rotated to 90° antenna was reconfigured to LHCP (Left Hand Circular Polarization). The simulation result expresses that polarization frequency reconfiguration of the antenna was attained from 8 – 11.2 GHz with 33.33% of fractional operating bandwidth by adjusting distance among metallic reflector, slot antenna, and metasurface. Moreover, 16.5dBi was the highest computed gain.

V. PENT-POLARIZATION RECONFIGURABLE METAMATERIAL ANTENNA

A metamaterial is an artificially built periodic array structure which consists of subwavelength cells. Regarding performance, it could be segmented to polarization conversion metasurface, CRLH (Composite Right or Left-Handed), PRS (Partially Reflective Surface) and electromagnetic bandgap, etc. If the antenna was designed with metamaterial as in [34-39], was exposed to excellent performance in terms of gain, profile, and bandwidth.

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In many applications Mushroom kind is CRLH structure, utilized in antenna's radiation patch. With TM_{20} and TM_{10} modes, mushroom type antenna proposed by Q. Chen et.al [36] had recognized boresight radiation and broadband working.

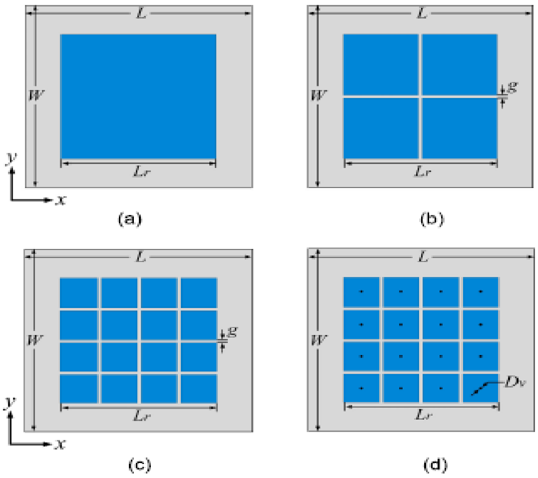

Figure 7: Radiation Structure a). Case-1, b). Case-2, c). Case-3, d). Case-4 [40]

According to [40] crossed H-shaped slot coupled Penta polarization reconfigurable antenna with metamaterial of mushroom type was used. Plane's electric filed components were represented as x and y. the electromagnetic wave could be shown as:

$$\overrightarrow{F_x} = \hat{x} F_{xn} e^{i\varphi_x} \quad (6)$$

$$\overrightarrow{F_y} = \hat{y} F_{yn} e^{i\varphi_y} \quad (7)$$

When y and x component had varied phase and amplitude, the polarization of plane electromagnetic wave was controlled as when:

- F_{yn} = 0, x-Linear Polarization was acquired.
- F_{xn} = 0, y-Linear Polarization was acquired.
- F_{xn} = F_{yn} , φ_{xn} = φ_{yn} , 45° Linear polarization was acquired.
- F_{xn} = F_{yn}, φ_{xn} - φ_{yn}, 90°, RHCP was acquired.
- F_{xn} = F_{yn}, φ_{xn} - φ_{yn}, -90°, LHCP was acquired.

In a way to attain all the above-said functions, the dual LP antenna was the right choice. Various polarization modes were produced by controlling phase and amplitude distribution of 2 ports of dual LP antenna. To attain broadband, low-profile reconfigurable antenna, there was a need to model higher performance dual LP antenna. The configuration of dual LP antenna is illustrated in Figure 8. 3 metallic layers were positioned on 2 F4B substrates. Both substrates had similar permittivity of ε_s = 3.5 and loss tangent of 0.002, substrates' total thickness was 3.5 mm and the equivalent relative height was $0.06\lambda_0$ at 5.2 GHz. Figure 8a expresses antenna's top layer, which was a mushroom kind metamaterial structure and Figure 8b represents the crossed H-shaped slot coupled structure. Related to CMA, x, and y LP modes of 2 wanted modes. To stimulate x-linear polarization and y-linear polarization modes, 2 crossed Y-shaped feeding lines were modeled as shown in Figure 8c. Inorder to minimize dielectric substrates' count, two feeding strips were modeled on the same layer. Y shaped feeding line was bridge connected so that overlapping of two feeding lines were removed.

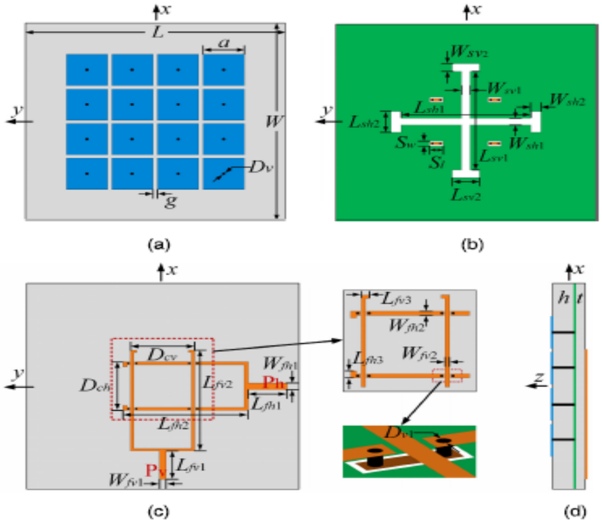

Figure 8: Dual Linear Polarization Antenna. a). The top layer, b). Ground layer, c). Bottom layer and d). Side view.

ANSYS HFSS software was utilized to simulate dual LP antenna to examine the feeding structure performance. It was observed that 2 LP modes were agitated efficiently and other modes were suppressed. When P_h horizontal port and P_v vertical port were excited separately, 10db fractional bandwidth of antenna was 27.2% and 23.1%. Within the operating band, the antenna had 2 radiation gain from 7.8 – 11.6 dBi in 2 polarized states, which was conducive to model CP and LP antenna of 45°. The simulation results reveals that balance was achieved among broadband and low-profile on Penta-polarization reconfigurability.

VI. DISCUSSION AND PROPOSED IDEA

Based on the study conducted, Metasurface find its application in wide range of reconfigurable structures. We are proposing a reconfigurable array structure for 5G application. The proposed idea is to implement an antenna array that is capable of Beam Steering along with Frequency and Polarization reconfiguration. The idea is to implement a basic radiating element array in the 5G band and design a suitable metasurface that is capable of resonating in the 5G band. The proposed structure achieves both frequency and polarization reconfiguration by rotating the structure and changing the relative position between the basic antenna and the metasurface. The beam steering can be implemented by providing suitable phase shift in feed provided to different elements in the array. The phase shift is implemented using Metasurface Split Ring Resonators (SRR). Using this approach, a single feedline can be used and properly introducing SRR phase shift can be introduced.

Retrieval Number:100.1/ijeat.C40310212323
DOI: 10.35940/ijeat.C4031.0212323
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VII. CONCLUSION

Various methods of reconfiguration including the use of PIN and Varactor diode is analysed, due to the use of additional biasing elements these antenna structures become complex. This can be avoided by the use of metasurface for reconfigurtion. Metasurface structures for frequency and polarization reconfiguration is studied. Metasurface are incorporated with the main radiating element as additional layer in almost all works. The asymmetry property of the metasurface is actively used in many of the works for achieving the reconfigurability. More than one layer of metasurface is implemented with main radiating element for achieving hybrid reconfigurability. In all these cases the structure become compactible and the use of additional biasing element is reduced. Metasurface antenna find its application in Wi-Max, Wi-Fi and various other C Band applications. Based on the study conducted we proposed an idea for developing a structure for 5G application which is capable of Frequency and Polarization reconfiguration along with Beam Steering.

DECLARATION

Funding/ Grants/ Financial Support	No, I did not receive.
Conflicts of Interest/ Competing Interests	No conflicts of interest to the best of our knowledge.
Ethical Approval and Consent to Participate	No, the article does not require ethical approval and consent to participate with evidence.
Availability of Data and Material/ Data Access Statement	Not relevant.
Authors Contributions	All authors have equal participation in this article.

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