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Review on Design Approach for Dual Frequency Patch Antennas

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Abstract: ***In numerous applications, operation in two distinct frequency bands which are far apart from each other is required. Here dual band antennas are used instead of broadband antennas. Also, dual-frequency patch antenna avoids the use of two antenna elements which makes a compact antenna structure. In many practical applications, two frequency bands must have the same polarization, radiation characteristics with good impedance matching at two distinct frequency bands. This article describes a study of dual frequency patch antennas. Methods for achieving tunable and dual frequency operation have been studied. A survey is conducted on normally used methods for dual frequency operation.***
Keywords: ***dual frequency patch antennas, resonant frequencies, operating modes, microstrip antenna (MSA), tunable, dual frequency operation.***

I. INTRODUCTION

The antenna is an important element in the communication system. In 1953 Deschamps first invented the concept of microstrip antenna (MSA) and practical MSAs were developed in the 1970s by Munson and Howell [1]. MSA are popular from decades for their attractive features, such as light weight, compact size, conformal to host surfaces, compatible with microwave monolithic integrated circuits (MMICs) and besides that MSAs have demerits such as they suffer from narrow bandwidth, low gain and low power handling capacity [2]. Dual frequency patch antennas are recently used in various applications where two distinct frequency bands are far apart. A dual-frequency patch antenna provides dual frequency operation on a single platform instead of two separate antenna elements. These antennas are tunable either of one or two frequencies, several techniques have been reported [2]. For achieving dual frequency operation there are three methods which are categorized as orthogonal mode dual-frequency patch antennas, multi-patch dual frequency patch antennas, and reactively loaded dual frequency patch antennas. Use of orthogonal mode dual frequency patch antennas [3], the dual-frequency operation can be obtained and TM_{10} and TM_{01} modes are generated with two frequencies have orthogonal polarization planes. A multi-patch dual-frequency patch antenna includes stacked element structure that uses triangular and rectangular [4], annular-ring [5], circular-disc [6] patches. Reactively loaded patch antenna uses slots [7-11], for dual frequency operation, the slot allows for effective modification of the resonant mode of a rectangular patch.

Use of two spur-line band-stop filters [12], notch [13], and shorting pin [14] for dual frequency operation reported. One of the methods for obtaining tunable and dual band operation is to add stub on MSA, for rectangular MSA stub may be placed either radiating or non-radiating edge of patch [15-16]. Dual frequency operation is also achieved by using lumped capacitors, varactors and diodes [17, 18].

In this article, brief overviews of methods for achieving dual frequency operation have been presented. An overview is conducted on normally used methods for obtaining dual frequency operation. Specifically, some single-layer designs that have been lately invented are demonstrated with a conclusion on overall methods.

II. METHODS FOR ACHIEVING DUAL FREQUENCY OPERATION

In perceptive, dual-frequency patch antenna have similar features, they have similar characteristics of radiation, polarization, and impedance [1]. Dual frequencies patch antennas recently used due to its attractive features. When it is essential to operate antenna at two different frequencies that are far apart, these dual frequency antennas are replaced in place of two separate antennas. A dual band operation is constant at two frequencies, or tunable at both or one of the frequencies.

The techniques for achieving dual frequency operation are classified as, orthogonal mode dual-frequency patch antennas; multi-patch dual frequency patch antennas and reactively loaded dual frequency patch antennas.

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A. Higher order or orthogonal mode dual-frequency patch antennas

Orthogonal mode dual-frequency patch antennas have two resonant frequencies with orthogonal polarization shown in Fig. 1. The orthogonal mode dual frequency operation can be obtained by using the single feed of dual feed. This method is used in low cost and short range applications, but a limitation of this method is that two different frequencies are generated with orthogonal polarization.

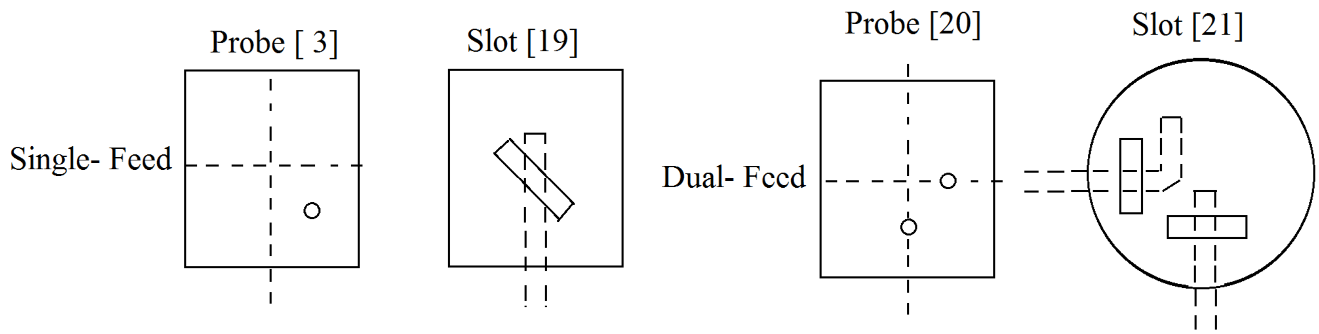

Fig. 1.Higher order or orthogonal mode dual-frequency patch antennas.

Orthogonal mode dual-frequency patch antennas can be obtained by using simple orthogonal fed rectangular MSA. In this simple rectangular MSA has a width of patch *W* and length of patch L. The two new resonant frequencies are generated f_{10} and f_{01} depend on L and W.

When feed point is at the orthogonal position, two resonant frequencies f_{10} and f_{01} can be obtained [3]. Another way to obtain orthogonal mode dual frequency operation, by using an inclined slot, in this case, the patch is excited through the inclined slot in the ground plane of the microstrip feed line. Two resonant frequencies are generated by TM_{01} and TM_{10} modes. The two frequencies have orthogonal polarization [19].

For single feed dual frequency MSA, if one frequency is utilized for transmission purpose and the other for reception purpose, to sequestrate the receiver from the transmitter, a diplexer or circulator is needed. Dual feed dual frequency MSA avoids the use of diplexer or circulator by feeding the rectangular MSA at two orthogonal points [20]. A circular patch is excited by two orthogonal microstrip lines through the two orthogonal slots cut in the ground plane. By altering dimensions of slots, dual band operation can be obtained with orthogonal polarization [21].

B. Multi-patch dual frequency patch antennas

By using multiple radiating elements, dual frequency operation can be obtained. At resonance, each radiating element establishes strong current distribution and radiation at resonance. A multi-patch dual-frequency patch antenna includes multi-layer stacked radiating patches that can use circular [6], annular ring [5], rectangular and triangular [4] patches. These antennas have dual polarization as well as similar polarization at two frequencies. By using cross-sub array patch antenna shown in Fig. 2, a dual-frequency operation with high-frequency ratio obtained [22].

Another approach for dual frequency operation, use of stacked element structure [23], [24]. These antennas have limited value of frequency ratio and they are applicable for short-link Transmit-receive modules or vehicular satellite applications.

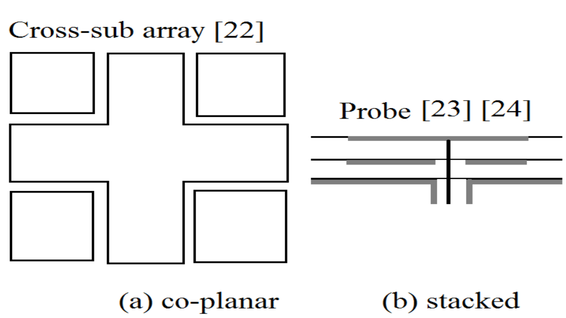

Fig. 2.Multi-patch dual frequency patch antennas.

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C. Reactively loaded dual frequency patch antennas

Reactively loaded dual frequency patch antennas are listed in Fig. 3. The common known technique for dual frequency operation is to use reactive loading technique to a single patch. The simplest way to obtain dual frequency operation is to add stub along radiating or non-radiating edges of rectangular MSA [15-17]. Other kinds of reactive loadings can be used, including slots [7], [27], notches [26], [12], and lumped capacitors [17], [18], and shorting pins [14].

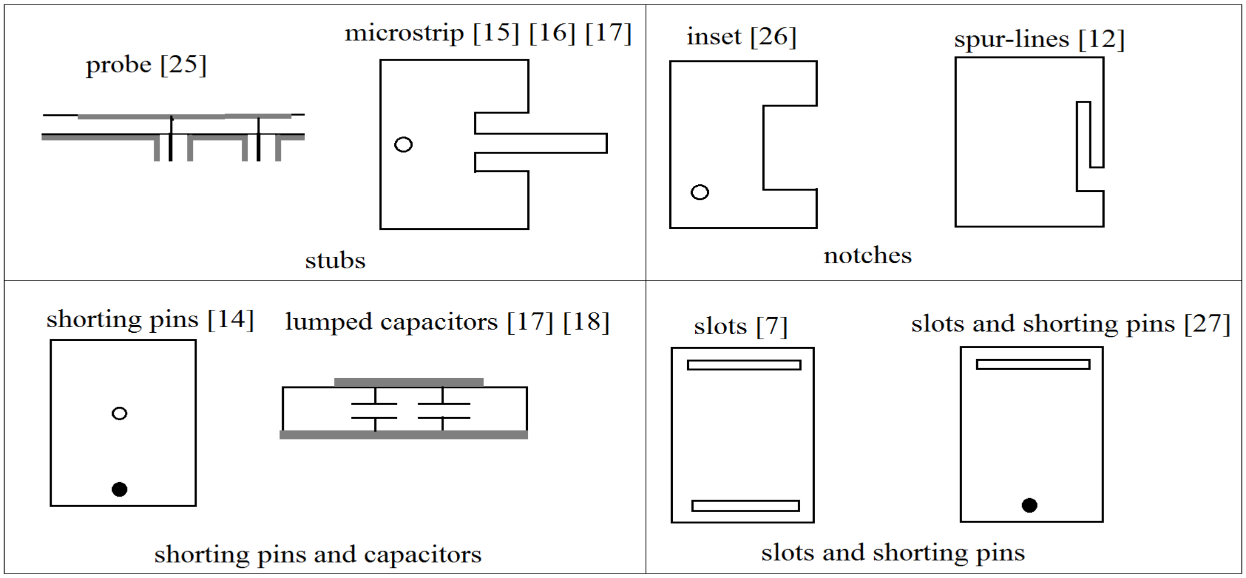

Fig. 3.Reactively loaded dual frequency patch antennas.

The first use of reactive loading approach used in [25], in which an adjustable coaxial stub was utilized. In the simplest way, this configuration allows tunable operation and frequency ratio and limited for low-frequency applications. An alternative way to introduce dual frequency operation is to use radiating edge with an inset [26] or spur-lines [12]. However, stubs and notches configuration can't maintain frequency ratio greater than 1.2.

Frequency ratio may be increased by using the shorting pins [14] or lumped capacitors [17], [18] between radiating patch and ground plane. Another way to introduce reactive loading is to create slots close and parallel to radiating edges [7], or non-radiating edges [11], dual frequency operation can be obtained with similar polarization, radiation characteristics and good impedance matching at two frequencies.

III.SOME DESIGNS FOR DUAL-FREQUENCY OPERATION

A. Dual-Frequency Operation with Orthogonal Polarization Planes

Fig. 4(a) shows the geometry of coaxial probe fed rectangular MSA for achieving dual-frequency operation with orthogonal polarization [3]. In this antenna, from the length and width of rectangular patch two operating frequencies are generated. The location of coaxial probe feed selected in such a way those two modes TM_{01} and TM_{10} are excited, at first and second operating frequencies. The antenna has been fabricated using copper-clad microwave substrate of thickness 0.762 mm and dielectric constant 3.0. The rectangular patch has dimensions of $60.6 \times 55.5\ mm^2$ were selected. The resonant frequencies formulated using the following expression as,

$$f_{mn} = \frac{c}{2\sqrt{\epsilon_r}}\sqrt{\left(\frac{m}{L}\right)^2 + \left(\frac{n}{W}\right)^2}$$

where $\in_r$ is relative permittivity and c is the speed of light in air.

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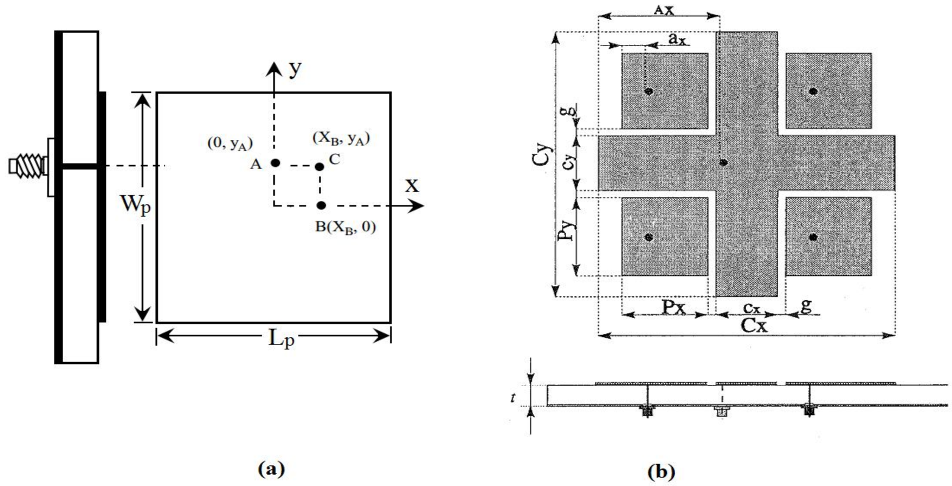

Fig. 4.(a) Rectangular MSA for Dual-Frequency Operation with Orthogonal Polarization Planes [3]; (b) Geometry Of Cross-Sub Array Dual-Frequency MSA [22].

The TM_{01} mode has been excited when coaxial probe feed placed at point A (along y- axis) and excitation of TM_{mo} mode, m=1,3,5…….., is rejected. Then again, when coaxial probe feed is placed at point B (along x-axis), TM_{10} mode is excited and excitation of TM_{on} mode, n= 1, 3, 5……., is rejected. The coaxial probe feed is placed at point C (x_B, y_A) for achieving dual-frequency operation with good impedance. Two resonant frequencies at 1.42 and 1.54 GHz were designed. A 50 Ω impedances have been obtained at point (9.6 mm, 0) (point B), for excitation of TM_{10} mode and at point (0, 9.5 mm) (Point A) for excitation of TM_{10} mode. By selecting feed point at (9.6 mm, 9.5 mm) (point C), two frequencies have been generated 1.42 and 1.54 GHz with orthogonal polarization and good impedance matching.

IV. CROSS-SUB ARRAY DUAL-FREQUENCY MSA

The Cross-sub array dual-frequency MSA geometry depicted in Fig. 4(b), and the antenna is tuned to a large value of frequency ratio [22]. The antenna consists of a cross patch operate at the lower frequency, and four square patches designed to operate at an upper frequency as a sub-array. The antenna has been designed for dual frequency arrays. In SAR applications require radiation in dual linear polarization, the antenna were designed to the required specification. For S- band application, a cross patch has been designed and for X- bands sub-array application, four patches were designed. The antenna has been realized on an RT/Duriod 5880 substrate with 2.2 dielectric constant and thickness of 0.8 mm.

The antenna allows dual frequency operation at frequencies 2.85 and 8.65 GHz respectively. The resonance of a cross patch is slightly perturbed by the four patches; radiating edges of the cross-patch are far from the four square patches. In counterpoint, the resonant frequency of four square patches pretends by the presence of a cross patch. Certainly, radiating edges of four square patches are close to the cross patch edge. This allows reactive loading of the four square patches that induces a virtual over-lengthening of the same four square patches. Thus the upper resonant frequency is slightly lower than that predicted for an isolated patch. The upper frequency is decreased when spacing *g* is lower than the height of the substrate.

The limitation for the above antenna for SAR application is narrow bandwidth at a lower frequency, which causes from single layer substrate.

V. SLOT LOADED RECTANGULAR MSA

Fig. 5 shows the geometry of slot loaded rectangular MSA. Two narrow rectangular slots of dimensions L_s and d are placed near the radiating edges of the rectangular patch and these dimensions are very less as compared to L and W. The coaxial probe feed is used to excite antenna. For rectangular MSA generally, three modes are excited in the cavity referred as TM_{100}, TM_{200}, and TM_{300}. These modes represent longitudinal currents distributed on the rectangular patch which has nulls at the radiating edges. In practical application, TM_{100} mode used subsequently the TM_{200} mode broadside null radiation characteristics and the TM_{300} mode generates grating lobe. When two slots are placed close and parallel to radiating edges of the rectangular patch, minor perturbation of TM_{100} are countered because slots are located close to current minima. The radiation characteristic for the first mode is same as that of the

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rectangular patch without slots. Therefore the resonant frequency of first mode slightly differs from rectangular patch without slots. On the other side, when slots are place close and parallel to radiating edges of the rectangular patch, strong perturbation of TM_{300} are countered because slots are located close to current maxima. Hence this current is strongly modified. The currents circulate around slots and find a resonant condition with nulls close to two edges of the rectangular patch. The lower frequency is same as that of the rectangular patch without slots; the upper frequency can be controlled by changing slot length.

The antenna provides tunable and dual frequency operation within the range 1.6 to 2. The two frequencies have same polarization and radiation pattern with good impedance matching.

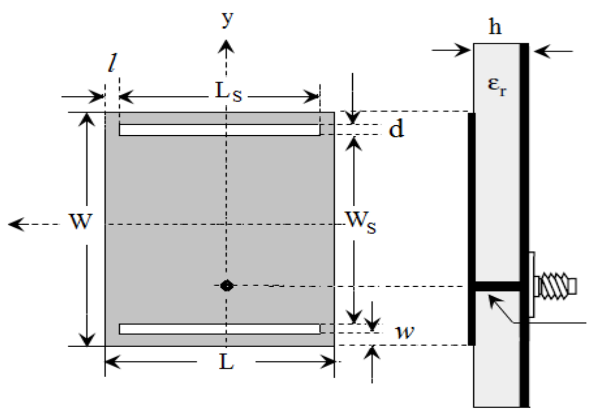

Fig. 5.Geometry Of Slot loaded rectangular MSA[28].

VI. CONCLUSIONS

A review on design approach for dual frequency patch antennas has been carried out, with primary emphasis on geometries that are commonly used for their ease and design flexibility. In the orthogonal mode, dual-frequency patch antennas are used in low cost and short range applications, but a limitation of this method is that two different frequencies are generated with orthogonal polarization. Another approach for dual frequency operation, use of stacked element structure, these antennas have limited value of frequency ratio and they are applicable for short-link transmit-receive modules or vehicular-satellite communications. Frequency ratio may be increased by using reactive loading approach that includes the shorting pins or lumped capacitors between radiating patch and ground plane.

REFERENCES

[1] G. Deschamps and W. Sichak, "Microstrip Microwave Antennas," Proceedings of the Third Symposium on the USAF Antenna Research and DevelopmentProgram,October 18-22, 1953.

[2] Kumar.G.and Ray K.P.,"Broadband Microstrip Antennas", Artech House, USA,2003.

[3] J. S. Chen and K. L. Wong, "A single-layer dual-frequency rectangular microstrip patch antenna using a single probe feed," Microwave Opt. Technol. Lett. 11, 83–84, Feb. 5, 1996. 34.

[4] D. Mirshekar-Syankal, H. R. Hassani, "Characteristics of Stacked Rectangular and Triangular Patch Antennas for Dual Band Application," IEE 8th International Conference on Antennas and Propagation, Edinburgh, March 1993.

[5] J. S. Dahele, K. F. Lee and D. P. Wong "Dual Frequency Stacked Annular-Ring Microstrip Antenna," IEEE Transactions on Antennas and Propagation, AP-35, 11, November 1987, pp.1281-1285.

[6] S. A. Long, M. D. Walton, "A Dual-Frequency Stacked Circular-Disc Antenna," IEEE Transactions on Antennas and Propagation, AP-27,3, March 1979, pp. 1281-1285.

[7] J. H. Lu and K. L. Wong, "Slot-loaded, meandered rectangular microstrip antenna with the compact dual-frequency operation," Electron. Lett. 34, 1048–1050, May 28, 1998.

[8] Ganesh M. Kale, R. P. Labade, and R. S. Pawase,"Open Rectangular Ring Slot Loaded Rectangular Microstrip Antenna For Dual-Frequency Operation", Microwave Opt Technol Lett, Vol. 57, No. 10, pp. 2448−2452, October 2015.

[9] U. Chakraborty, Member, IEEE, A. Kundu, S. K. Chowdhury, and A. K. Bhattacharjee, "Compact Dual-Band Microstrip Antenna for IEEE 802.11a WLAN Application", Antenna and wireless propagation letters, IEEE, vol. 13, pp.407-410,2014.

[10] Amit A. Deshmukh and K. P. Ray "Formulation of Resonance Frequencies for Dual-band slotted Rectangular Microstrip Antennas", IEEE Antennas and Propagation Magazine, Vol. 54, No. 4, pp.78-97, August 2012.

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Volume 5 Issue VI, June 2017
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

[11] Kale Ganesh M, Labade R. P., and Pawase R. S., "Tunable And Dual Band Rectangular Microstrip Antenna For Bluetooth And WiMAX Applications", Microwave Opt Technol Lett, Vol. 57, No. 8, pp. 1986-1991, August 2015.

[12] David Sanchez-Hernaindez, Georgios Passiopoulos, Ian D Robertson,"single-fed dual-band circularly polarized microstrip patch antennas",26th EuMC, 9-12 September 1996, Hotel Hilton Atrium,Prague Czech Republic.

[13] Rajesh Kumar Vishwakarma, Ravi Kumar, "Rectangular Notch Microstrip Antenna for Dual-Band Operation", International conference on recent advances in microwave theory and applications, pp.675-677, 2008.

[14] Shi-Chang Gao, Le-Wei Li, Tat-Soon Yeo, and Mook-Seng Leong,"Small Dual-Frequency Microstrip Antennas", IEEE Trans. Antennas Propagat.on vehicular technology, vol. 51, no. 1, pp. 28-36, January 2002.

[15] A. A. Heidari, M. Heyrani, And M. Nakhkash,"A Dual-Band Circularly Polarized Stub Loaded Microstrip Patch Antenna For Gps Applications", Progress In Electromagnetics Research, PIER 92, 195–208, 2009.

[16] Plessis, M. Du., and J. H. Cloete, ''Tuning Stub for Microstrip Patch Antenna,''IEEE AP-S Int. Symp. Digest, June 1993, pp. 964–967.

[17] Junyan Tang, Raoul O. Ouedraogo, Member, Edward J. Rothwell, Alejandro R. Diaz, and Kazuko Fuchi,"A Continuously Tunable Miniaturized Patch Antenna ", IEEE Antennas Wireless Propag. Lett., Vol. 13, pp. 1080-1083, 2014.

[18] Behrouz Babakhani and Satish K. Sharma,"Wideband Frequency Tunable Concentric Circular Microstrip Patch Antenna With Simultaneous Polarization Reconfiguration", IEEE Antennas and Propagation Magazine, Vol. 57, No. 2, pp. 203-216, April 2015.

[19] Y. M. M. Antar, A. 1. Lttipiboon, A. K. Bhattacharyya,"A Dual-Frequency Antenna Using A Single Patch And An Inclined Slot", Microwave Opt Technol Lett, Vol. 8, No. 6,pp. 309-311, April 20 1995.

[20] Srinivasan, V., K. P. Ray, and G. Kumar, ''Orthogonal Polarized Microstrip Antennas,'' Proc. NSAML-2000, Delhi, India, March 2000, pp. 43–46.

[21] Murakami, Y., et al., ''Dual Slot Coupled Microstrip Antenna for Dual Frequency Operation,'' Electronics Letters, Vol. 29, October 1993, pp. 1906–1907.

[22] C. Salvador, L. Borselli, A. Falciani, S. Maci, "A Dual Frequency Planar Antenna at S and X Bands," Electronics Letters, 31, 20, October 1995, pp. 1706-1707.

[23] S. A. Long, M. D. Walton, "A Dual-Frequency Stacked Circular-Disc Antenna," IEEE Transactions on Antennas and Propagation, AP-27,3, March 1979, pp. 1281-1285.

[24] J. S. Dahele, K. F. Lee and D. P. Wong "Dual Frequency Stacked Annular-Ring Microstrip Antenna," IEEE Transactions on Antennas and Propagation, AP-35, 11, November 1987, pp.1281- 1285.

[25] W. F. Richards, S. E. Davidson, S. A. Long, "Dual-Band Reactively Loaded Microstrip Antenna," IEEE Transactions on Antennas and Propagation, AP-33, 5, May 1985, pp. 556-560.

[26] H. Nakano, K. Vichien "Dual-Frequency Patch Antenna with a Rectangular Notch," Electronics Letters, 25, 16, 1989, pp. 1067-1068.

[27] B. F. Wang and Y. T. Lo, "Microstrip Antenna for Dual-Frequency Operation," IEEE Transactions on Antennas and Propagation, AP-32, 9, September 1984, pp. 938-943.

[28] S. Maci, G. Biffi Gentili, P. Piazzesi, C. Salvador "A Dual-Band Slot-Loaded Patch Antenna," IEE Proceedings-H, 142, 3, March 1995, pp. 225-232.

[29] K. L. Wong and W. S. Chen, "Compact microstrip antenna with the dual-frequency operation," Electron. Lett. 33, 646–647, April 10, 1997.

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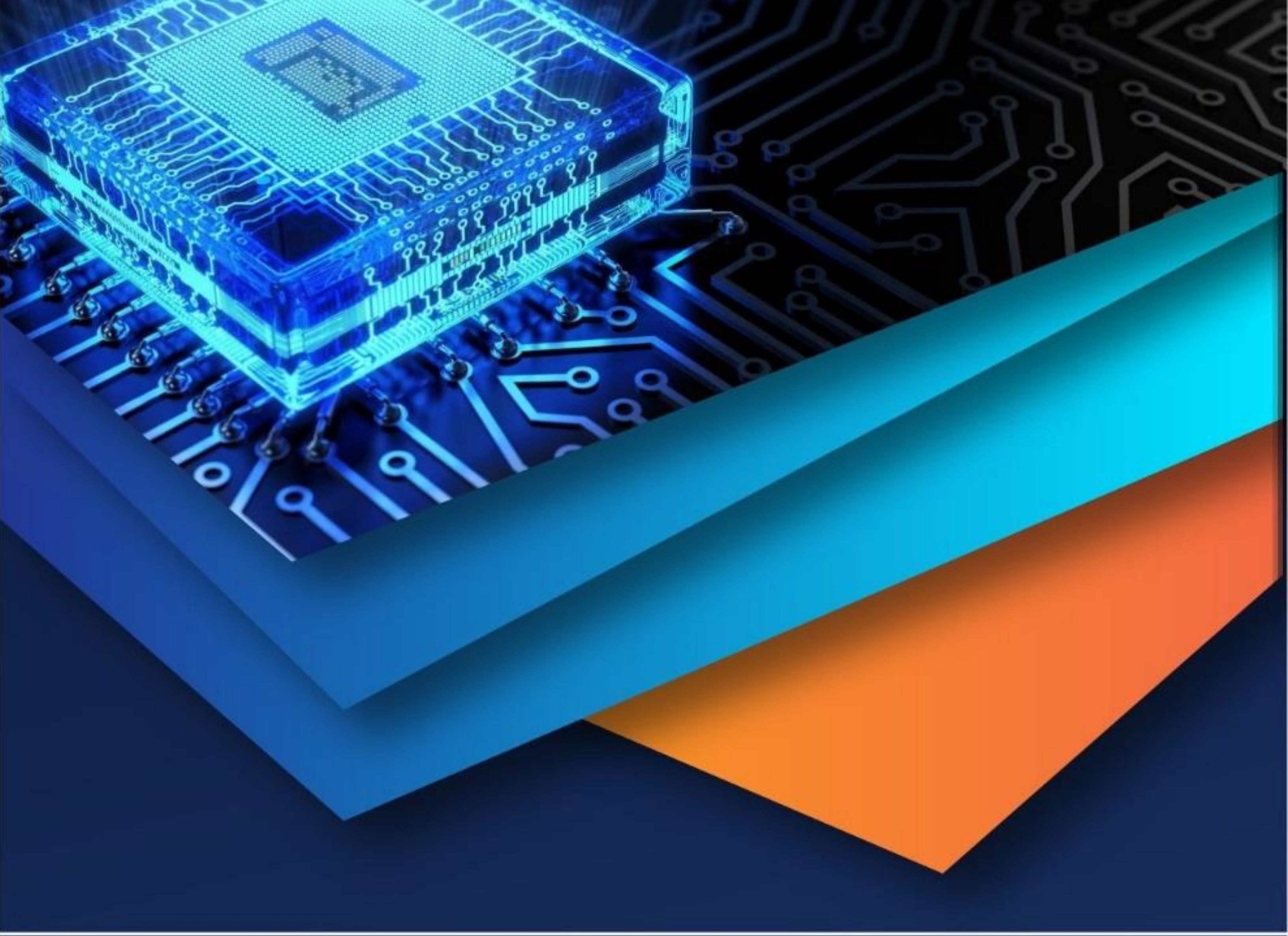

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