Educational Administration: Theory and Practice
2024, 30(6)(s), 195-201
ISSN: 2148-2403
https://kuey.net/
Research Article

Analysis Of Vedic Shaped Microstrip Patch Antenna (MPA) Design For Wireless Applications

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Citation: Mr. Nirav J. Chauhan et al, (2024 Analysis Of Vedic Shaped Microstrip Patch Antenna (MPA) Design For Wireless Applications , *Educational Administration: Theory and Practice*, *30*(6)(s) 195-201
Doi: 10.53555/kuey.v30i6(S).5354

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ABSTRACT

With the rapid progress in the field of wireless communication, the demand for antenna with miniature size and light weight becomes a necessary requirement in today's world. Most suitable antenna in this category is "Microstrip Patch Antenna (MPA)". In this paper parametric analysis of MPA design structure as per footprint equations, Substrate material, Feeding Techniques and Design parameters are analyzed keeping in view of various Vedic shapes. SSMPA has been recently developed by the researchers which has exhibited improved radiation properties with improved polarization. The design of the SSMPA has been taken from a holy sign in Hindu mythology and has exhibited enhancement in the bandwidth of an MPA. The slots of the SSMPA help in modifying the surface current distribution of the patch. The shape basically helps the charge particles in accelerating and decelerating, which improves the bandwidth and radiation characteristics. Antenna parameters like "Gain, S11 (Return Loss), Bandwidth, Directivity, VSWR" are to be compared for various designs respect to wireless applications. This paper looks at the Swastika and other Vedic shaped MPA and the various advantages of its usage for wireless applications.

Keywords—Microstrip patch antenna (MPA), Wideband antennas, Gain, Bandwidth, Directivity, S_{11} (Return Loss), "Swastika Shaped Microstrip Patch Antenna" (SSMPA), VSWR

I. INTRODUCTION

An antenna serves as a specialized transducer, converting radio frequency (RF) fields into alternating current (AC) or vice versa. As wireless communication technology advances, the imperative for lightweight and compact antennas has grown in today's world. Leading the way in this category is the Microstrip Patch Antenna (MPA), a popular choice known for its low profile and adaptability for mounting on flat surfaces. These antennas comprise a flat rectangular metal sheet or "patch" positioned over a larger metal sheet known as a ground plane. Typically housed within a protective plastic radome, this assembly safeguards the antenna structure from
potential harm. [5]

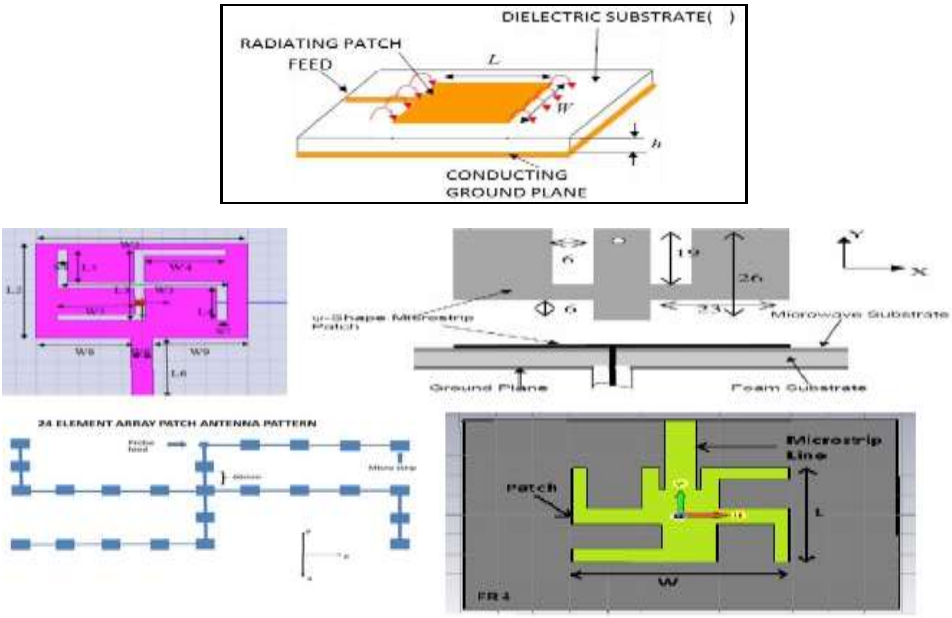

Figure 1: Few Vedic shaped MPA [2] [3] [4] [10]

Radiation in MPA predominantly emanates from the edges where the patch meets the ground plane due to the influence of fringe fields. This radiation intensifies with higher frequencies, elevated substrate thickness, lower permittivity
values, and is notably initiated at points of discontinuity. [41]

The design of a MPA necessitates consideration of the following prerequisites:

o Shape of patch o Substrate type o Substrate thickness o Patch Dimensions o Feeding technique o Resonant frequency

[6]	2019	10 GHz, 28 GHz, 2.5 GHz	Square MPA by varying the substrate height	RT Rogers duroid substra te is used CST softwar e is employ ed to conduc t simulat ions.	With increasing substrate thickness (h), the resonance frequency decreases but the bandwidth increases.
[7]	2017	746787 MHz, 18501990 MHz, 19202170 MHz, and 36003700 MHz	Rectangular MPA with DGS of Swastik Shape	HFSS softwar e is employ ed to conduc t simulat ions.	With this structure gain of the antenna is slightly improved. It is used in wireless multi band applications as this antenna obtained multiband.
[8]	2015	2.4 GHz	Analysis of MPA with Different Shapes of Patch	FR4 substra te is used CST softwar e is employ ed to conduc t simulat ions.	Rectangular patch shows better results than triangular and circular patch with FR-4 dielectric at 2.4 GHz frequency.
[9]	2014	4.1 to 14.6 GHz	Rectangular MPA (Swastik slot loaded) fed by a Microstrip line	FR4 substra te is used HFSS softwar e is employ ed to conduc t simulat ions.	This antenna design gives I.B. of 10.5 GHz operating over a range of frequencies 4.1 to 14.6 GHz with VSWR < 2 suitable for various UWB applications
[10]	2015	2.4 GHz	Swastika Shaped Microstrip Patch Antenna	CST softwar e is employ ed to conduc t simulat ions.	This design has efficient output parameters than conventional and regular slotted MPA resonates at 2.416 GHz, i.e. ISM band frequency

[11]	2013	2.5 GHz	A novel shape MPA	IE3D software e is employ ed to	The innovative geometry of the patch antenna shape yields a substantial
Paper	**Year**	**Freque ncy**	**Antenna Proposed**	**Techn ology used**	**Advantages**
[1]	2022	UWB (3.1 GHz - 14 GHz)	A Flower Shaped Miniaturize d 4 x4 MIMO Antenna	CST softwar e is employ ed to conduc t simulat ions.	Provides miniaturization and offers a good wide band. Inserting a Swastik-shaped stub on the ground gives Return losses.
[2]	2022	Penta band- 2.9/5.2/ 6.9/8.2 and 12.9G Hz), suitabl e for 5G sub- GHz applica tions	SWASTIK shaped slotted MSPA antenna	FR4 substra te ι:(r = 4.4) is used HFSS software e is employ ed to conduc t simulat ions.	The current flow is altered by the Swastika shaped slot which resonates at the 5 bands. Power efficiency in SSMPA is better than rectangular.
[3]	2009	4-7 GHz	A novel ψshape Microstrip patch antenna	HFSS software e is employ ed to conduc t simulat ions.	The antenna exhibits an impedance bandwidth of 55%, maintaining acceptable radiation patterns across most frequencies, with the exception of 7 GHz, where higher cross-polarizations were observed.
[4]	2017	2.25 GHz	Novel MPA Array	HFSS software e is employ ed to conduc t simulat ions.	As the quantity of patch elements rises, so does the Gain and Directivity.
[5]	2018	2.4 GHz	Comparativ e Analysis of Microstrip Patch Antenna Performanc e: Swastika vs. Rectangular Shapes	HFSS software e is employ ed to conduc t simulat ions.	The rectangular MPA displays an omni-directional radiation pattern, while the SS MPA exhibits a directional radiation pattern.

II. CURRENT STATE OF WORK IN SSMPA AND VARIOUS VEDIC SHAPES

				conduct simulat ions.	bandwidth ensuring commendable performance in terms of VSWR.
[12]	2020	1500M Hz, 1076M Hz	Circularly Polarized Swastik Shape Microstrip Antenna	IE3D softwar e is employ ed to conduct simulat ions.	This antenna yields broadside gain of above 6 dBi over most of the impedanc bandwidth with peak gain close to 7 dBi which finds applications in mobile base station communication antennas as well as in personal communication systems.
[13]	2016	2.63 GHz, 4.79 GHz	MPA for Space Application s	FR4 epoxy substra te of dielectr ic permitt ivity 4.4 and loss tangent 0.0002 is used	The final variant has a maximum gain at 2.63 GHz with a bandwidth of 10 MHz to be used for fixed satellite, mobile except aeronautical mobile and broadcast satellite applications.

			ntary SplitRing Resonator	simulat ions.	with metamaterial works in X, Ku, and K bands.
[18]	2015	2.15G Hz and 3.98G Hz.	Swastik Slot MPA	IE3D softwar e is employ ed to conduct simulat ions.	By cutting the Swastik slot, bandwidth and gain are improved.
[19]	2015	2.4GH z	Rectangular MPA with DGS	HFSS softwar e is employ ed to conduc t simulat ions.	By introducing a defect in the ground plane and altering its shape, we observed corresponding variations in the characteristics, specifically in relation to the specified resonant frequency
[20]	2021	3.5 GHz	Patch Array Antenna for Health Care and Monitoring System	Not specifi ed Simula tion Softwa re.	The results show a considerable increase in the gain of the overall antenna

				HFSS software is employed to conduct simulations.	
[15]	2018	2.16 GHz to 4.24 GHz	Modified star MPA	HFSS software is employed to conduct simulations.	This antenna has wideband characteristics from 2.16 GHz to 4.24 GHz with good impedance bandwidth.
[16]	2016	0.6 GHz- 2 GHz	Slotted H-shape MPA	HFSS software is employed to conduct simulations.	H-shape antenna has better performance in the specified frequency range
[17]	2020	12GHz - 20GHz	Swastik Slotted Hexagonal MPA With Metamaterial-Based Compleme	HFSS software is employed to conduct	The proposed Swastik slotted hexagonal patch antenna works in Ku and K bands whereas the same antenna integrated
[23]	2018	15 GHz	Perturbed Array of Circular Patch antenna	HFSS software is employed to conduct simulations.	The main purpose is to enhance the gain and directivity of antenna by implementing more number of patches.
[24]	2016	1.4 GHz	Triangle shape MSP Antenna for GPS Applications	IE3D software is employed to conduct simulations.	Triangle shape Microstrip patch is very useful for wideband application.
[28]	2018	5.4/5.8 GHz	Swastika-Slot Circular MPA for WLAN and WiMAX Applications	HFSS software is employed to conduct simulations.	Radiation Pattern is better in this MPA.
[35]	2015	3.935 GHz to 4.955 GHz	Broadband MPA with diff. slots Loaded At the Centre and Fixed Double Cross Slot at the edges	IE3D software is employed to conduct simulations.	Expanding the number of slots in the swastika configuration can enhance the broadband characteristics while maintaining the same dimensions.

III. CONCLUSION

The analysis demonstrates that the Swastika and other Vedic shaped Microstrip patch antenna have garnered significant research interest among researchers and the following are some observations from the various works: Varying the shape of the patch enhances bandwidth, The utilization of unequal arm lengths contributes to enhancing the antenna's performance, The current flow is altered by the Swastika shaped slot which resonates at the multiple bands, Truncated and DGS assist in radiation pattern.

Hence MPA with Different Shapes of Patch, various DGS shapes, sizes, locations, Feeding Methods and different substrate gives better enhancement in bandwidth, gain as well as reduction in return loss.

[36]	2023	5.9 GHz and 27 GHz	Dual Band MPA with DGS	HFSS software is employed to conduct simulations.	MPA with various DGS shapes, sizes, locations, and different substrate gives better enhancement in bandwidth.
[44]	2017	3.38 GHz	Rectangular micro-strip patch antenna employing Flipped Swastika design	HFSS software is employed to conduct simulations.	This antenna operates in the 3.38 GHz frequency with good return loss, it is useful for the WiMax application.
[47]	2021	9 GHz	Metamaterial Loaded Microstrip Antenna for Defense Applications	HFSS software is employed to conduct simulations.	The metamaterial unit cell is specifically crafted to achieve near-total absorption at precisely 9 GHz. This design holds relevance in stealth technology, particularly in defense applications such as military aircraft, space vehicles, missiles, ships, and other critical transportation means. Its utilization aids in minimizing radar cross-section (RCS) for effective longdistance wireless communication.
[49]	2018	0.99G Hz, 1.16G Hz, 1.54G Hz, 1.98G Hz	A Novel MPA for Navigational Application	HFSS software is employed to conduct simulations.	Proposed slot MPA has good amount of gain also having VSWR in good range.
[55]	2016	Bluetooth (2.42.48 GHz), Ultra Wide Band (UWB) (3.1-0.6GHz), Xband (8-12 GHz) and	Multiband MPA for UWB, Bluetooth, X-band and Ku band Applications	CST software is employed to conduct simulations.	The suggested grounding scheme presents a highly effective method that significantly enhances the impedance bandwidth of the antenna, making it well-suited for ultra-wideband and various other applications.

1.	2.	3. 4. 5.	Ku band (12-18 GHz)	6.	7.	8.

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