



A Survey on Micro strip Patch Antenna and its Applications

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Abstract: The realm of microstrip patch antennas has undergone significant advancements in recent years. In comparison to traditional antennas, microstrip patch antennas offer a myriad of advantages and exhibit promising prospects. These antennas boast characteristics such as reduced weight, compact dimensions, cost-effectiveness, minimal profile, ease of manufacturing, and enhanced conformity. Furthermore, their versatility extends to providing dual and circular polarizations, accommodating dual-frequency operations, displaying frequency agility, possessing broad bandwidth capabilities, enabling feedline flexibility, and facilitating beam scanning with omnidirectional patterning. This paper delves into an extensive exploration of microstrip antennas, encompassing various types, feeding techniques, and applications. The discussion encompasses the advantages and disadvantages of microstrip patch antennas in contrast to conventional microwave antennas. By examining these attributes, the paper aims to elucidate the considerable potential and diverse functionalities offered by microstrip patch antennas across various applications in the field of microwave technology.

Key Words: Microstrip Antenna (MSA), Microstrip patch antenna (MPA), Applications

I. INTRODUCTION

Antennas, the wizardry of wireless communication, act as sorceries transducers, conjuring electromagnetic waves into existence or capturing their ethereal essence. Among these mystical devices, the enigmatic microstrip antennas emerge as radiant stars, outshining their conventional microwave counterparts across myriad practical applications. Behold, in the tome of technology, the elemental form of microstrip antennas unfurls its simplicity, as illustrated in the sacred scroll of Fig1. In the grand tapestry of electromagnetic marvels, these microstrip antennas weave a tale of unparalleled advantages: lighter, sleeker, and more versatile than their antiquated counterparts. Their elegant simplicity belies their prowess, offering a symphony of benefits that resonate across the realms of wireless communication. It consists of a radiating patch on one side of dielectric substrate ($\epsilon_r \leq 10$), which has a ground plane on other side.

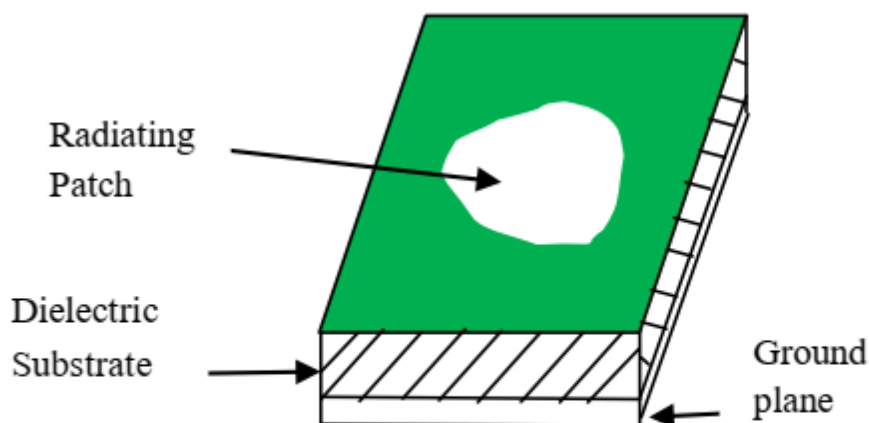
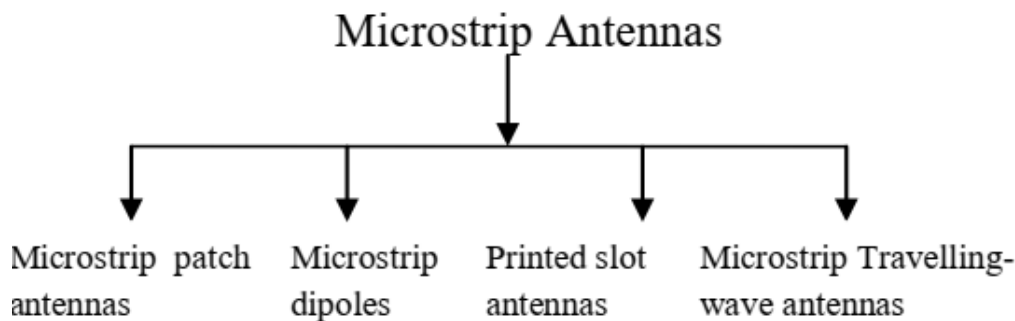


Fig 1: Microstrip antenna configuration

Microstrip antennas, in their ethereal complexity, possess a tapestry of physical parameters, a rich palette of dimensions, and a diverse array of geometrical shapes that far surpass the realm of conventional microwave antennas. Unlike their simpler counterparts, these marvels of modern engineering dance amidst a labyrinth of possibilities, offering a canvas vast and varied for design and manipulation.



Their allure lies not just in their functionality but in their versatility—each parameter a brushstroke on the canvas of electromagnetic transmission. From the curvature of their contours to the intricacies of their dimensions, microstrip antennas resonate with a symphony of choices. Their geometric forms, akin to artistic masterpieces, can take shape as squares, circles, rectangles, triangles, or even more exotic configurations, offering engineers and creators a trove of options to craft antennas tailored to specific applications. Furthermore, these antennas beckon with a myriad of dimensions, each influencing the antenna's behavior and performance. The length, width, thickness, spacing, and substrate material entwine to orchestrate the antenna's resonance, polarization, bandwidth, and radiation pattern. In the ever-evolving landscape of wireless communication, the vast spectrum of possibilities offered by microstrip antennas beckons the curious and the innovative, inviting exploration and experimentation to harness their boundless potential. Their diversity in shapes and dimensions not only fuels technological advancement but also ignites the imagination, inspiring the pursuit of new frontiers in antenna design and engineering [1-2]. All microstrip antennas can be divided into four basic categories:



II. MICROSTRIP PATCH ANTENNA

A microstrip patch antenna, often referred to as an MPA, manifests as a finely crafted symphony of components, carefully arranged upon the stage of a dielectric substrate. Its essence lies in the marriage of a conducting patch, sculpted into any geometric form, adorning one side of this substrate, while a grounding plane holds steadfast on the other. This union births a marvel—a resonant antenna steeped in elegance and functionality. Primarily cherished for its prowess in catering to narrow-band microwave wireless links, the microstrip patch antenna unveils its specialty—a penchant for providing semi-hemispherical coverage. Its design, encapsulated within a planar structure, seamlessly integrates with microstrip technology, fostering an aura of ease and adaptability that resonates across the realms of antenna engineering.

This antenna, the darling of researchers and engineers alike, has undergone meticulous scrutiny, its virtues extolled through a multitude of studies. In the annals of scientific inquiry, a compendium awaits—an exhaustive catalogue chronicling a plethora of geometries, each adorned with distinct features and virtues. This treasury stands as a testament to the diversity and innovation that thrives within the realm of microstrip patch antennas, offering a cornucopia of shapes and characteristics to suit diverse applications and bespoke requirements. In the grand tapestry of microstrip antennas, the rectangular and circular patches stand as venerable titans—the bedrock upon which the symphony of wireless communication unfolds. These stalwarts, adorned in their quintessential forms, serve as the cornerstone for both the rudimentary and the most intricate of applications.

The rectangular patch, with its crisp angles and defined edges, emerges as a paragon of simplicity and versatility. Its nature, easily dissected and comprehended, lends itself gracefully to applications spanning from the mundane to the most exacting. In the realm of analysis, it unfolds its secrets readily, a canvas upon which engineers paint their designs with ease and precision.

Contrastingly, the circular patch, with its graceful curvature, whispers tales of symmetry and elegance. Within its circular embrace lies the advantage of a radiation pattern so exquisitely balanced and symmetric that it becomes a beacon of harmony amidst the cacophony of electromagnetic waves. Its allure lies not just in its form but in its grace—a siren call to applications that seek the beauty of symmetry in their radiation patterns. These patches, rectangular and circular, stand as heralds of the microstrip world, beckoning engineers and dreamers alike to unlock their potential. In their simplicity and symmetry, they serve as gateways to a realm where wireless communication finds its voice and resonance. A rectangular microstrip patch antenna in its simplest form is shown in Figure 2.

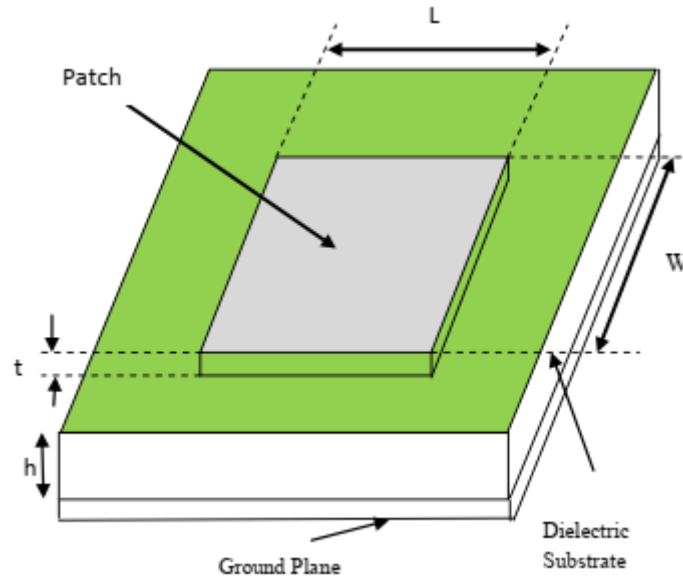


Fig 2: Structure of rectangular microstrip patch antenna

The characteristics of microstrip patch antennas, microstrip slot antennas and printed dipole antennas are compared in table 1.

Table.1 Comparison table

Sr. No	Characteristics	Microstrip Patch Antenna	Microstrip Slot Antenna	Printed Dipole antenna
1.	Profile	Thin	Thin	Thin
2.	Fabrication	Very easy	Easy	Easy
3.	Polarization	Both linear and circular	Both linear and circular	Linear
4.	Dual-Frequency operation	Possible	Possible	Possible
5.	Shape flexibility	Any shape	Mostly rectangular and circular shapes	Rectangular and triangular
6.	Spurious radiation	Exists	Exists	Exists
7.	Bandwidth	2-50%	5-30%	-30%

III. APPLICATIONS

Microstrip patch antennas stand as beacons of performance and resilience within the realm of antenna design and fabrication. Their robust nature and stellar performance have elevated them to a position of prominence, carving a niche marked by versatility and reliability. These antennas, born from a quest to overcome shortcomings and harness advantages, have emerged as veritable champions in various domains. Their inherent advantages, ranging from facile design processes to their feather-light weight, serve as pillars upon which their widespread usage is built. The allure of these microstrip patch antennas extends across diverse fields, finding purpose in the sanctums of medical applications, where precision and reliability are paramount. They soar into the celestial expanse aboard satellites, securing their place as pivotal instruments in communication and data transmission. Moreover, their significance echoes in the hallowed



halls of military systems, adorning rockets, aircraft, and missiles with their prowess, ensuring robust connectivity and communication even in the most demanding and dynamic environments. As their usage spans across such varied domains, the proliferation of microstrip antennas knows no bounds. Their tendrils of influence extend into every sector, poised to revolutionize communication systems, both commercially and industrially. This ascent is further propelled by their cost-effectiveness in substrate materials and fabrication, marking them as economically viable solutions amidst a sea of alternatives. The horizon gleams with the promise of a future where microstrip patch antennas reign supreme, poised to potentially overshadow conventional antennas in a myriad of applications. Their utility is boundless, and their applications, as diverse as the imagination permits. In the symphony of technological advancement, these antennas compose a harmonious melody, orchestrating connectivity and communication in ways that continue to redefine the boundaries of possibility.

Mobile and satellite communication application: When it comes to mobile communication, antennas need to be small, cheap, and not stick out too much. That's where the microstrip patch antenna comes in—it ticks all those boxes. Different kinds of microstrip antennas have been made specifically for mobile communication systems. For satellite communication, we need antennas that send out circularly polarized signals. That can be done using square or circular patches with one or two feed points. It's all about tweaking the design to get the right kind of signal pattern needed for those satellite connections.

Global Positioning System applications: Today, for GPS, we're using microstrip patch antennas with a special kind of material in the base that helps them work better. These antennas are small, circularly polarized, and super compact, but they can be a bit pricey because they're really good at finding precise positions. It's predicted that loads of GPS devices—millions of them—will be used by regular folks in cars, planes, and boats to pinpoint their exact location.

Radio Frequency Identification (RFID): RFID is handy in lots of places—think mobile communication, shipping, making stuff, getting around, and even healthcare [2]. It works with frequencies between 30 Hz and 5.8 GHz, depending on what it's being used for. At its core, an RFID system is like a tag or a chip and a reader that talks to it. Simple as that!

Worldwide Interoperability for Microwave Access (WiMax): WiMax, also known as IEEE 802.16, is like a supercharged Wi-Fi. It's designed to cover big areas—up to 30 miles in theory—and zip data around at 70 Mbps. Microstrip patch antennas (MPA) are part of this magic. They produce three special modes at 2.7, 3.3, and 5.3 GHz, making them perfect for gear that follows the WiMax rules for communication.

Radar Application: Radar spots moving things like people and cars. To make the radar work well, it needs a small, light antenna system. That's where microstrip antennas shine. They're perfect because they can be made using a special way called photolithography, making lots of them quickly and cheaper than the old-style antennas. Plus, they keep the radar setup nice and light!

Rectenna Application: A rectenna, short for rectifying antenna, stands as a marvel in the world of wireless power. It's a unique type of antenna that works its magic by directly transforming microwave energy into usable DC power. This innovation combines four essential components: the antenna itself, an ore rectification filter, a rectifier, and a post-rectification filter. In the realm of rectenna application, the design of the antenna takes center stage. It's crucial to craft antennas with exceptionally high directive characteristics to meet the rigorous demands of long-distance links. The ultimate goal is to utilize the rectenna to wirelessly transfer DC power across vast distances, a feat that hinges upon increasing the electrical size of the antenna. This increase in size isn't just about physical dimensions—it's about enhancing the antenna's electrical properties. By scaling up these characteristics, the antenna can effectively capture and harness microwave energy, ensuring efficient conversion into usable direct current. This enhancement becomes pivotal when striving for extended wireless power transmission, making it feasible to bridge substantial gaps while maintaining an optimal power transfer efficiency. In essence, the quest for elongating the electrical size of the antenna within rectenna systems is a cornerstone in enabling the transmission of DC power wirelessly over expansive distances. It's a testament to the ingenuity and innovation driving advancements in wireless power technology.

Telemedicine Application: In telemedicine, there's an antenna doing its thing at 2.45 GHz. This special wearable microstrip antenna works great for Wireless Body Area Networks (WBAN). It's designed to be worn and does a cool job—it gets a stronger signal and a better way of sending it out compared to other antennas. This antenna stands out because it's not blasting signals in every direction like a light bulb; it's more focused, kind of like a flashlight. That's good because it means less unnecessary signal going into the user's body. This is important for both on-body and off-body uses.



The numbers that show how well this antenna works are a gain of 6.7 dB and a front-to-back ratio of 11.7 dB, and it hums at 2.45 GHz. These features make it just right for telemedicine applications, helping doctors and patients connect more effectively and safely.

Medicinal applications of patch: When it comes to treating tough cancers, like malignant tumors, using microwave energy to create hyperthermia has proven super effective. For this job, the radiator used needs to be light, easy to handle, and tough. That's where the patch radiator shines—it meets all these requirements. At first, the designs for these Microstrip radiators used printed dipoles and annular rings, working in the S-band. Later on, they switched to circular microstrip disks in the L-band. These designs were tweaked and improved to work best for this specific purpose. The tool used here is pretty straightforward: two connected Microstrip lines have a flexible separation that measures the temperature inside the body. The flexible patch applicator, shown in the picture, operates at 430 MHz, playing a crucial role in this cancer treatment technique.

IV. ADVANTAGE AND DISADVANTAGE

The microstrip patch antenna has a bunch of upsides compared to regular microwave antennas, but they both work in the same frequency range, from 100 MHz to 100 GHz. If you peek at table 2, you'll see a list of the different pros and cons of each type.

Sr. No.	Advantage	Disadvantage
1.	Low weight	Low efficiency
2.	Low profile	Low gain
3.	Thin profile	Large ohmic loss in the feed structure of arrays
4.	Required no cavity backing	Low power handling capacity
5.	Linear and circulation polarization	Excitation of surface waves
6.	Capable of dual and triple frequency operation	Polarization purity is difficult to achieve
7.	Feed lines and matching network can be fabricated simultaneously	Complex feed structures require high performance arrays

V. CONCLUSION

This paper delves into the theoretical landscape of microstrip patch antennas, aiming to uncover potential solutions to their drawbacks. Within this exploration lies the quest to mitigate certain disadvantages—like lower gain and limited power handling capacity—by leveraging the power of array configurations. By harnessing the strength of multiple antennas working together, these limitations can be minimized, enhancing performance. The selection of the feeding technique plays a pivotal role in antenna design. Various factors come into play here, guiding the choice of the most suitable method. This tailored approach allows for the creation of specific microstrip patch antennas, finely tuned for diverse applications. Each design is meticulously crafted to meet the unique demands of its intended use, highlighting the array of advantages when compared to conventional microwave antennas. In essence, this survey illuminates the pathway toward optimizing microstrip patch antennas. By strategically utilizing array configurations, fine-tuning feeding techniques, and tailoring designs to fit specific applications, the aim is to elevate these antennas to new heights while emphasizing their comparative strengths over traditional microwave counterparts.



REFERENCES

- [1]. James j., and P.S. Hall (Eds), Handbook of microstrip antenna, Peter Peregrinus, London, UK, 1989.
- [2]. Ramesh Garg, Prakash Bartia, Inder Bahl, Apisak Ittipiboon, ‘*Microstrip Antenna Design Handbook*’, 2001, pp 1-68, 253-316 Artech House Inc. Norwood, MA.
- [3]. Wentworth M. Stuart (2005), ‘*Fundamentals of Electromagnetic with Engineering Applications*’, pp 442-445, John Wiley & Sons, NJ, USA.
- [4]. J. D. Kraus, R. J. Marhefka, “*Antenna for all applications*” 3rd Ed., McGraw- Hill, 2002.
- [5]. Robert A. Sainati, CAD of Microstrip Antennas for Wireless Applications, Artech House Inc, Norwood, MA, 1996.
- [6]. Y T Lo and S W Lee, editors, ‘*Antenna Handbook Theory, Applications & Design*’, Van Nostrand Rein Company, NY, 1988.
- [7]. C.A. Balanis, *Antenna theory: analysis and design, 2nd ed.*, John Willey and & Son, Inc., 1997.