

Design of gap coupled antenna using micro strip patch

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Desired Patch antenna design is minimally simulated by using HUFFS. And Patch antenna is realized as per design requirements. The advantages of microstrip antennas have made them a perfect candidate for use in the wireless local area network (WLAN) applications. Though bound by certain disadvantages, microstrip patch antennas can be tailored so they can be used in the new high-speed broadband WLAN systems. This paper presents the design of rectangular patch multilayer antennas for the 2.4 GHz ISM band. A microstrip antenna consists of a conducting patch on a ground plane separated by a dielectric substrate.

This concept was undeveloped until the revolution in electronic miniaturization and large-scale integration in 1970. After that many authors have described the radiation from the ground plane by a dielectric substrate for different configurations. The early work of Munson on microstrip antennas for use as a low profile flush mounted antenna on rockets and missiles showed that this was a practical concept for use in many antenna system problems. Various mathematical models were developed for this antenna and its applications were extended to many other fields.

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The number of papers, articles published in the Journals for the last ten years, on these antennas shows the importance gained by them. The micro strip antennas are the present day antenna designer's choice. Low dielectric constant substrates are generally preferred for maximum radiation. The conducting patch can take any shape but rectangular and circular configurations are the most commonly used configuration. Other configurations are complex to analyze and require heavy numerical computations. A microstrip antenna is characterized by its Length, Width, Input impedance, and Gain and radiation patterns.

Various parameters of the microstrip antenna and its design considerations were discussed in the subsequent chapters. The length of the antenna is nearly half wavelength in the dielectric; it is a very critical parameter, which governs the resonant frequency of the antenna. There are no hard and fast rules to find the width of the patch. Waves on Microstrip The mechanisms of transmission and radiation in a microstrip can be understood by considering a point current source (Hertz dipole) located on top of the grounded dielectric substrate (fig. 1) This source radiates electromagnetic waves.

Depending on the direction toward which waves are transmitted, they fall within three distinct categories, each of which exhibits different behaviors.

Fig. Hertz dipole on a microstrip substrate Surface Waves The waves transmitted slightly downward, having elevation angles θ between $\pi/2 - \arcsin(1/\sqrt{\epsilon_r})$, meet the ground plane, which reflects them, and then meet the magnitude of the field amplitudes builds up for some particular

incidence angles that leads to the excitation of a discrete set of surface wave modes; which are similar to the modes in metallic waveguide.

The fields remain mostly trapped within the dielectric, decaying exponentially above the interface (fig. 2). The vector a , pointing upward, indicates the direction of largest attenuation. The wave propagates rationally along p , with little absorption in good quality dielectric. With two directions of a and orthogonal to each other, the wave is a non-uniform plane wave. Surface waves spread out in cylindrical fashion around the excitation point, with field amplitudes decreasing with distance (r), sally $[r$, more slowly than space waves.

The same guiding mechanism provides propagation within optical fibers. Surface waves take up some part of the signal's energy, which does not reach the intended user. The signal's amplitude is thus reduced, contributing to an apparent attenuation or a decrease in antenna efficiency. Additionally, surface waves also introduce spurious coupling between different circuit or antenna elements. This effect severely degrades the performance of microspore filters because the Fig. 2 parasitic interaction reduces the isolation in the stop bands.

In large periodic phased arrays, the effect of surface wave coupling becomes particularly obnoxious, and the array can neither transmit nor receive when it is pointed at some particular directions (blind spots). This is due to a resonance phenomenon, when the surface waves excite in synchronism the Fluent modes of the periodic structure. Surface waves reaching the outer boundaries of an open microspore structure are reflected and diffracted by

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the edges. The diffracted waves provide an additional contribution to radiation, degrading the antenna pattern by raising the side lobe and the cross polarization levels.

Surface wave effects are mostly negative, for circuits and for antennas, so their excitation should be suppressed if possible. **Guided Waves** When realizing printed circuits, one locally adds a metal layer on top of the substrate, which modifies the geometry, introducing an additional reflecting boundary. Waves erected into the dielectric located under the upper conductor bounce back and forth on the metal boundaries, which form a parallel plate waveguide. The waves in the metallic guide can only exist for some Particular values of the angle of incidence, forming a discrete set of waveguide modes.

The guided waves provide the normal operation of all transmission lines and circuits, in which the electromagnetic fields are mostly concentrated in the volume below the upper conductor. On the other hand, this buildup of electromagnetic energy is not favorable for patch antennas, which behave like resonators with a limited frequency bandwidth. **Leaky Waves** Waves directed more sharply downward, with θ angles between $-\arcsin(1/n)$ and n , are also reflected by the ground plane but only partially by the dielectric-to-air boundary.

They progressively leak from the substrate into the air (Fig 1. 3), hence their name leak waves, and eventually contribute to radiation. The leaky waves are also which may appear to be rather odd; the amplitude of the waves increases as one moves away from the dielectric surface. This apparent

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paradox is easily understood by looking at the figure. 3; actually, the field amplitude increases as one move away from the substrate because the wave radiates from a point where the signal amplitude is larger.

Since the structure is finite, this apparent divergent behavior can only exist locally, and the wave vanishes abruptly as one crosses the trajectory of the first ray in the figure. In more complex structures made with several layers of different dielectrics, leaky waves can be used to increase the apparent antenna size and thus provide a larger gain. This occurs for favorable stacking arrangements and at a particular frequency. Conversely, leaky waves are not excited in some other multilayer structures. Fig. 3 Leaky Waves

Antenna Characteristics An antenna is a device that is made to efficiently radiate and receive radiated electromagnetic waves. There are several important antenna characteristics that should be considered when choosing an antenna for your application as follows: ; Antenna radiation patterns ; Power Gain ; Directivity ; Polarization Advantages and Disadvantages Microstrip patch antennas are increasing in popularity for use in wireless applications due to their low-profile structure. Therefore they are extremely compatible for embedded antennas in handheld wireless devices such as cellular phones, pagers etc...

The telemetry and communication antennas on missiles need to be thin and conformal and are often in the form of Microstrip patch antennas. Another area where they have been used successfully is in Satellite communication. Some of their principal advantages are given below: ; Light weight and low <https://assignbuster.com/design-of-gap-coupled-antenna-using-micro-strip-patch/>

volume. ; Low profile planar configuration which can be easily made conformal to host surface. ; Low fabrication cost, hence can be manufactured in large quantities. ; Supports both, linear as well as circular polarization. ; Can be easily integrated with microwave integrated circuits (MIC). Capable of dual ND triple frequency operations. ; Mechanically robust when mounted on rigid surfaces. Microstrip patch antennas suffer from more drawbacks as compared to conventional antennas. Some of their major disadvantages are given below: ; Narrow bandwidth ; Low efficiency ; Low Gain ; Extraneous radiation from feeds and junctions ; Poor end fire radiator except tapered slot antennas ; Low power handling capacity. ; Surface wave excitation the losses associated with the antenna where a large Q leads to narrow bandwidth and low efficiency. Q can be reduced by increasing the thickness of the dielectric substrate.

But as the thickness increases, an increasing fraction of the total power delivered by the source goes into a surface wave. This surface wave contribution can be counted as an unwanted power loss since it is ultimately scattered at the dielectric bends and causes degradation of the antenna characteristics. Other problems such as lower gain and lower power handling capacity can be overcome by using an array configuration for the elements. Feed Techniques Microstrip patch antennas can be fed by a variety of methods. These methods can be classified into two categories- contacting and non-contacting.

In the contacting type, the RF power is fed directly to the radiating patch using a connecting element such as a microstrip line. In the non-contacting

scheme, electromagnetic field coupling is done to transfer power between the microstrip line and the radiating patch. The four most popular feed techniques used are the microstrip line, coaxial probe (both contacting schemes), aperture coupling and proximity coupling (both non-contacting schemes). **Microstrip Line Feed** In this type of feed technique, a conducting strip is connected directly to the edge of the Microstrip patch as shown in Figure 4.

The conducting strip is smaller in width as compared to the patch and this kind of feed arrangement has the advantage that the feed can be etched on the same substrate to provide a planar structure. Fig. 4: Microstrip line feed The purpose of the inset cut in the patch is to match the impedance of the feed line to the patch without the need for any additional matching element. This is achieved by properly controlling the inset position. Hence this is an easy feeding scheme, since it provides ease of fabrication and simplicity in modeling as well as impedance matching.

However as the thickness of the dielectric substrate being used, increases, surface waves and spurious feed radiation also increases, which hampers the bandwidth of the antenna. The feed radiation also leads to undesired cross polarized radiation. **Coaxial Feed** The Coaxial feed or probe feed is a very common technique used for feeding Microstrip patch antennas. As seen from Figure 5, the inner conductor of the coaxial connector extends through the dielectric and is soldered to the radiating patch, while the outer conductor is connected to the ground plane. Fig. : Probe fed Rectangular Microstrip Patch Antenna any desired location inside the patch in order to

match with its input impedance. This feed method is easy to fabricate and has low spurious radiation. However, a major disadvantage is that it provides narrow bandwidth and is difficult to model since a hole has to be drilled in the substrate and the connector protrudes outside the ground plane, thus not making it completely planar for thick substrates ($h > 0.02 \lambda_0$). Also, for thicker substrates, the increased probe length makes the input impedance more inductive, leading to matching problems.

It is seen above that for a thick dielectric substrate, which provides broad bandwidth, the microstrip line feed and the coaxial feed suffer from numerous disadvantages. The non-contacting feed techniques which have been discussed below, solve these issues. Aperture Coupled Feed In this type of feed technique, the radiating patch and the microstrip feed line are separated by the ground plane as shown in Figure 6 below. Coupling between the patch and the feed line is made through a slot or an aperture in the ground plane. Fig. : Aperture-coupled feed The coupling aperture is usually centered under the patch, leading to lower cross-polarization due to symmetry of the configuration. The amount of coupling from the feed line to the patch is determined by the shape, size and location of the aperture. Since the ground plane separates the patch and the feed line, spurious radiation is minimized. Generally, a high dielectric material is used for bottom substrate and a thick, low dielectric constant material is used for the top substrate to optimize radiation from the patch .

The major disadvantage of this feed technique is that it is difficult to fabricate due to multiple layers, which also increases the antenna thickness.

This feeding scheme also provides narrow bandwidth. Proximity Coupled Feed This type of feed technique is also called as the electromagnetic coupling scheme. As shown in Fig. Below, two dielectric substrates are used such that the feed line is between the two substrates and the radiating patch is on top of the upper substrate.

The main advantage of this feed technique is that it eliminates spurious feed radiation and provides very high bandwidth (as high as 13%), due to overall increase in the thickness of the microstrip patch antenna. This scheme also provides choices between two different dielectric media, one for the patch and one for the feed line to optimize the individual performances. Matching can be achieved by controlling the length of the feed line and the width-to-line ratio of the patch. The major disadvantage of this feed scheme is that it is difficult to fabricate because of the two dielectric layers which need proper alignment.

Also, there is an increase in the overall thickness of the antenna. Table 2: summarizes the characteristics of the different feed techniques: Rectangular Patch Antenna In its most fundamental form, a microstrip patch antenna consists of a radiating patch on one side of a dielectric substrate which has a ground plane on the other side. The patch is generally made of conducting material such as copper or gold and can take any possible shape. A microstrip antenna is characterized by its Length, Width, Input impedance, and Gain and radiation patterns. In this design the inset feeding technique is used.

The mathematical formulation to calculate the length, width and inset feed point are given below. The length (L), Width (W), and inset feed length have been calculated by generating a code in MUTUAL. By using these values the rectangular patch antenna has been designed on the FRR substrate with the dielectric constant of 4.4 and height of 1.5 mm in HUFFS software. The optimum design is given below in Figure 9. Fig. 9: conventional design Table 2: Comparative analysis between calculated and measured value:

Parameters	Calculated value(mm)	Measured value(mm)
Length	29.8	29
Width	38.04	
Feeding length	14.9	

The simulated results are given below. Fig. Return loss plot vs.. Frequency. Return loss = -10.90 db Fig. 5 VOWS plot vs.. Frequency VOWS = 1.7975 Fig. Radiation Pattern Game = 0. Db. Using inset feed technique: In gap coupling technique, two rectangular patches of equal dimensions are placed side by side along the length. Only the main patch is fed and other identical patch is parasitically coupled along the radiating edge of the central fed patch. Addition of one more patch to the conventional patch as parasitic element along the length will increase the bandwidth approximately one and half times.

The equivalent input impedance of two patches has been calculated for the fixed gap. The gap can be varied from 0.5 mm to 1 mm. In this design the gap length is 0.5 mm. The optimum design is given below. Fig. Gap coupled design using inset feed technique Fig. Return loss plot vs.. Frequency Return loss = -14.89 db Fig. VOWS plot vs.. Frequency VOWS = 1.44 Game = 1. Db Using transformer coupled feeding technique: The above discussions show that the gain of the antenna is not sufficient. The reflection loss has been improved in the second design.

To further improve the addition performance the same gap coupled antenna has been designed for the gap length of 3. Mm and in this design a transformer coupled feeding technique has been used. Fig. Gap coupled design using transformer feeding technique The simulated results are given below: Return loss = -11. 58 db Fig. VOWS plot vs.. Frequency. VOWS = 1. 7591 Gain = 2. 285 db Table 3: Comparative analysis of Conventional and Modified designs

Parameters	Conventional design	Gap coupled antenna with inset feed	Gap coupled antenna with coupled transformer feed
Return loss	-10. 91 db	-14. 89 db	-11. 58 db
Gain	0. Db	1. 66 db	2. 285 db
WAR	1 . 975	1 . 44	1 . 7591

Conclusion In this project, a conventional design and the gap coupled antenna have been described. The analysis of the designs show that a very low gain is achieved in the conventional design but in the gap coupled antenna a parasitic element is placed of same width and length and in this modified design the gain is improved due to the parasitic patch. Gap coupled antenna has been designed using two feed techniques: inset feed technique and transformer coupled feed technique. In the former design the reflection loss and gain has improved but in the later design the gain improvement is appreciable.