Review of Feeding Technique in Microstrip Patch Antenna

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Abstract

The basic design of a microstrip patch antenna consists of a metallic patch printed on a grounded substrate. The microstrip patch antenna can be easily understood by various approaches. These approaches can be verified in two categories, viz., contacting and non-contacting. In the contacting approach, the patch is straight fed with RF power by means of a contacting element such as a microstrip line or coaxial line. Electromagnetic field coupling is done in the non-contacting method to transfer power between the radiating patch and the microstrip line. Microstrip line, Coaxial probe, Aperture coupling and Proximity coupling are the four most popular feeding techniques. Basics of the microstrip antenna, different feeding methods, and antenna constraints are presented through this literature survey.

Keywords

Microstrip Antenna, Feeding Techniques, Radiation Pattern, VSWR

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Introduction

Here insert a microstrip antenna includes two major sides of a metallic configuration one fitted on the dielectric substrate and ground plane on the further side of the sub strate as displayed in Figure 1. Copper, gold is used for making a patch. Since they are eligible to make some probable arrangement. The radiating patch and the feed line are displayed generally on the dielectric substrate. There are various types of patch forms such as rectangular, c ircular, annular ring, and Equilateral triangle. The patch antenna impression was major planned in the early 1950s[1]. Compatibility with integrated circuit technology, low ease of manufacture and small profile are the advanta ges of the microstrip antenna. Its main demerit is fine bandwidth which is usually less than 5%. The low profile benefit was mostly good for fast running vehicles such as missiles, aircraft, and space craft's. In order to make simpler and easier analysis and performance estimation, there are various types of patch shapes such as rectangular, circular, annular ring and Equi lateral triangle. Under the guidance of a dense dielectric substrate that has less dielectric constant, this offers higher bandwidth and improves radiation and efficiency. However, this configuration causes a large size of the antenna. In order to decrease the antenna size a higher dielectric constant is used.

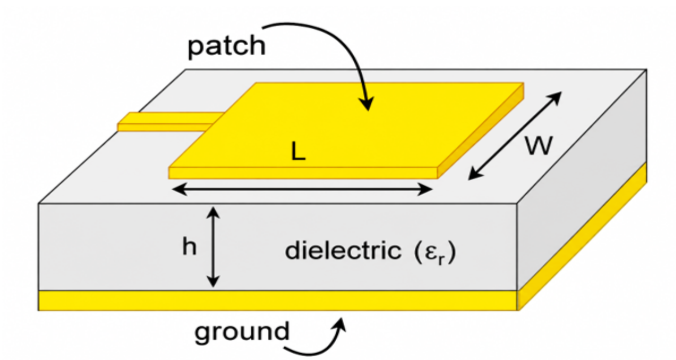

Figure 1. Microstrip patch antenna structure.

Literature Review

The texts on Microstrip Patch Antennas (MPAs) are huge, containing several research articles in archival journals. In the Distinctive Topic of IEEE Proceedings in 1992, titled "Antenna", Prof. D. M. Pozar wrote a review article on microstrip antennas[2]. In the review article published in the Henry G. Booker Memorial Issue in 1989[3], Lee predicted that "We can appear onward to sustained research in MPAs for quite some time to come." There were also numerous assessment articles and records, a limited list of which is given in[4–9]. Practically, the microstrip antenna was made useful by the development of Printed Circuit Board (PCB), microwave techniques and many kinds of low-attenuating media materials. Feeding design in a microstrip patch antenna is a main task in antenna designing for compatibility[10–12].

Feeding Techniques

The function of the feed is to radiate by the direct or indirect connection[13–15]. The feed of microstrip antenna consists of various arrangements viz., offset microstrip line, coaxial feed, aperture coupling feed nd proximity coup ling feed. In fact, coaxial feeds and microstrip line are comp aratively easier to fabricate. Coaxial feed is easily operated at 50 Ω at several points. These points are obtained with the aid of mathematical method.

Microstrip Line Feed

The Figure 5 shows a conducting strip associated straight to the verge of the microstrip patch. The conducting strip is thinner than the patch. The benefit is that the feed can be easily engraved on the same substrate to produce a perfectly balanced planar structure. Hence this is an informal feeding technique since it offers simplicity in modeling and ease of fabrication and impedance matching. Surface waves and false feed radiation rise when the thickness of the dielectric material rises, which fetters the bandwidth of the antenna. It results in an undesirable cross polarization.

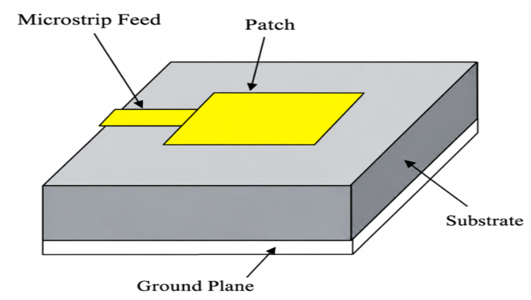

Figure 2. Microstrip line feed.

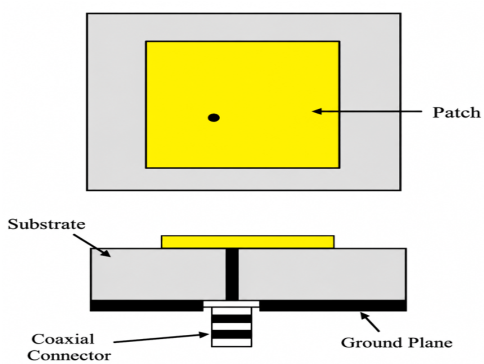

Figure 3. Coaxial feed

Coaxial Feed

Another name of this technique is the probe feed and it is one of the utmost mutual techniques. Figure 4 shows the outer conductor is connected to the ground plane and the inner conductor of the coaxial connector extends through the dielectric and is soldered to the radiating patch. The merit of this feeding arrangement is that the feed can be situated at some location inside the patch in order to obtain impedance matching. This is informal to operate and has fewer radiation effects. The main demerit of this method is that it offers narrow bandwidth and is tough to operate.

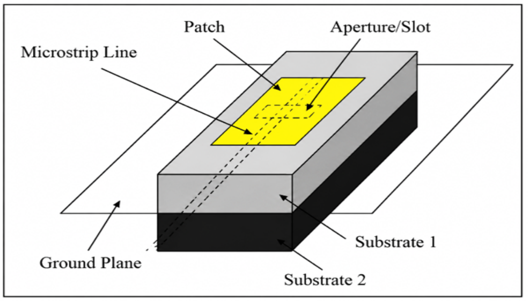

Figure 4. Aperture coupled feed

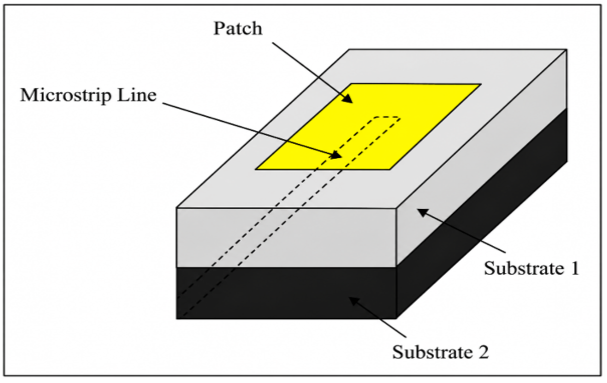

Figure 5. Indirect feed

Aperture Coupled Feed

Figure 4 shows the hard surface of the top of the antenna substrate contains the radiating microstrip patch element and the bottommost hard surface of the feed substrate contains the microstrip feed line. The width and the dielectric constant of these two substrates optimize the different electric function of radiation and circuitry. It is hard to manufacture due to several layers, which also leads to an increase in antenna thickness, and this is the chief disadvantage of this feed technique.

Proximity Coupled Feed

Another name of this technique is the electromagnetic coupling arrangement. Figure 5 shows two dielectric substrates arranged in such a manner that a fixed feed line is between the two substrates. The upper substrate contains the radiating patch. This method is helpful since it provides right feed radiation and very high bandwidth. The two dielectric layers that need proper alignment are difficult to fabricate, and this is a major disadvantage. Also, the overall thickness of the antenna is increased.

Antenna Parameters

Return Loss, Voltage Standing Wave Ratio, Antenna Gain, Directivity, Antenna Efficiency, and Bandwidth are the different antenna parameters.

Gain

The gain is not an amount which can be well-defined in relation with a physical quantity such as Watt or Ohm. It is a dimensionless ratio. The gain of the antenna in a particular path is the amount of energy radiated in the provided direction as compared to the energy of an isotropic antenna that would radiate in the same direction under the same input power. Gain is given by:

$$G = 4\pi \cdot U(\theta, \Phi)/P_{in} \tag{1}$$

where $U(\theta, \Phi)$ represents intensity in a particular direction and P_{in} is the input power.

Radiation Pattern

A graphical demonstration of the comparative supply of the radiated power in space is known as the radiation pattern.

Antenna Efficiency

The ratio of the complete power radiated by an antenna to the complete input power of the antenna.

VSWR

A new way to understand what method the system is matched, VSWR (Voltage Standing Wave Ratio) can be used. VSWR is the fraction of the maximum voltage and minimum voltage in the transmission line, and can be defined as follows:

$$\text{VSWR} = \frac{1+\rho}{1-\rho} \tag{2}$$

where ρ is the scale of $|\Gamma|$. The reflection coefficient is nearly 0 when the system is matched, while the VSWR is nearly 1.

Return Loss

Return loss is defined as the power of the reflected signal in a transmission line. It can be computed by the following equation:

$$\text{RL (dB)} = -20\log_{10}\Gamma \tag{3}$$

The return loss is also stated as the S_{11} of the S-parameters and is given in dB.

Bandwidth

Antenna bandwidth is the range of operational frequencies of the antenna near the resonance frequency.

Study of Antenna Designing Parameters

The three crucial constraints for designing a rectangular microstrip patch antenna are as follows. Initially, the resonant frequency (f_0) must be picked out correctly. The second essential constraint of the antenna is the substrate width, the height of the dielectric substrate (h). The third main parameter of a good antenna project is the dielectric substrate (ε_r). A dense dielectric substrate having a small dielectric constant is needed which delivers better efficiency, bandwidth, and radiation. A small amount of dielectric constant increases the fringing area at the patch boundary and consequently lowers the quality factor Q and increases the radiated power. The patch acts as a conductor. This configuration of the antenna has a patch length L, thickness W, the height of the dielectric substrate h and loss tangent. The main project parameter is the dielectric constant of the substrate substance. These are located on an endless ground level. The transmission line method is used to calculate antenna parameters[16].

Width of the Patch

$$W = \frac{c}{2f\sqrt{\dfrac{\varepsilon_r + 1}{2}}} \tag{4}$$

James et al. determined the antenna width in 1989, where c = speed of light in free-space.

Resonant Frequency

$$f_o = \frac{c}{2L_e\sqrt{\varepsilon_r}} \tag{5}$$

The length L_e, Effective length is given by,

$$L_e = L + 2\Delta L \tag{6}$$

The actual patch length L is given as (Pozar et al., 1995). The extended length ΔL due to the fringing effect is calculated by the following equation:

$$\Delta L = 0.412\,h \frac{(\varepsilon_{reff} + 0.3)\left(\dfrac{W}{h} + 0.264\right)}{(\varepsilon_{reff} - 0.258)\left(\dfrac{W}{h} + 0.8\right)} \tag{7}$$

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left(1 + \frac{12h}{W}\right)^{-\frac{1}{2}} \tag{8}$$

where, h = height of dielectric substrate
W = width of the patch.

Conclusion

This paper presents a theoretical study on the microstrip patch antenna and concludes that lower power control capacity and lower gain can be surpassed by an array structure and inserted patch. The review of this paper covers the designing steps and antenna design parameters involved. It means the designing approach of any microstrip patch antenna basically depends mainly upon the substrate and shape of the antenna. But according to applications it also depends upon the feeding method. It is clear that the antenna designing technique also involves the feeding technique because of conductor loss.

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