Overview on Feeding Techniques of Microstrip Patch Antenna

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***Abstract*—Antennas in general, patch antenna in particular, have been studied during the past six decades by a large number of researchers and graduate students specialized in microwave engineering because of its many advantages. As this type of antenna have many uses in the fields of wireless communication. In terms of design, this antenna has several layers stacked on top of each other and numbering three. The three layers are mediated by a layer of insulating material called the substrate layer. As for the first layer, it is called the patch and it consists of a conductive material such as copper. Finally, the third layer is called the ground plane and consists of the same material as the first layer. One of the advantages of this antenna is that it is easily integrated with the rest of the communication system devices because of its flat shape. What matters in the design of the antenna is the values of its coefficients, the most important of which is the input impedance. Therefore, the importance of choosing the appropriate feeding technique for the antenna in its application is evident. In this report, the existing feeding techniques for the patch hobby will be presented.**

Keywords—microstrip patch antenna, feeding techniques, microstrip line feed, co-axial feed, aperture coupled feed, proximity coupled feed

I. INTRODUCTION

Wireless communication devices such as cellular mobile phones, Radio Frequency Identification (RFID) systems, tablets, GPS devices, laptops, satellite phones, receivers, AM and FM radios are used on a daily basis and some of these devices are used by everyone. Wireless communication systems consist of several components, the most important of which are antennas. Where, the antenna plays the most important role in the process of sending and receiving electromagnetic signals over the air [1]. With an element of the importance of the antenna, it must be designed in a thoughtful way and with great care to get the best performance for the communication system as a whole.

The researchers were especially interested in the patch antenna, because of its attractive specifications, and it can be used as a solution to most of the challenges and problems facing scientific research and industries such as the industrial property industry and others [2]. One of the most attractive characteristics of this type of antenna is its low profile nature and its ability to integrate with all electronic circuits of communication systems, making it the most suitable solution for most industries, the most important of which is the mobile industries. The printed circuit is the technology used to produce this type of antenna. It was first produced in the fifties of the twentieth century. However, the popularity of these antennas did not begin until the early eighties. Careful analysis is used in developing theories of this sleep of antennae.

Feeding techniques are a very important component of all antennas, and the patch antenna is no exception. Where it is considered to be the operating part of the antenna and the part from which electromagnetic signals are received to be sent to the ether or vice versa. The type of feed used can influence in one way or another main characteristics of the antenna [3]. One of the most important characteristics that affect the choice of feeding sleep is the characteristics of radiation. One of the most important characteristics that must be taken care of when choosing the type of feeding is the entry resistance because it has a direct effect on the antenna performance.

II. MİCROSTRİP PATCH ANTENNA

The patch antenna is one of the most important and widely used printed antennas. Three layers stacked on top of each other are the usual components of the typical patch antenna. Where the last layer is made of metal materials and is called ground plane [4]. We note that the first layer is also made of the same conductive material from which the last layer is made. The patch is what is called the first layer. Between the first and the last layer there is the second layer. It consists of different materials from the other two layers, as it consists of an insulating material called the substrate layer. This type of antenna takes several forms, including star, square, pyramidal, triangle, circular, parabola, and many other shapes that resemble letters such as the letter F and the [5] letter Y. Each of these shapes has certain properties and certain uses. Some of them are used for wide ranges, others for multi-domains. This type of antenna is distinguished from the rest of the other types by its ease of design. Where this feature enabled it to spread its use in many wireless communication applications such as; its use in mobile devices, tablets and smart watches from Apple and Galaxy companies. This type of antenna has been the subject of research for many researchers and graduate students because of its many properties that can solve many of the challenges associated with modern wireless communication technologies such as the fourth and fifth generation of communications. The planer engineering resulted in the simplicity of manufacturing this antenna as well as the integration of the communication system devices with it [6]. It is not hidden from anyone how cheap the production of this antenna is as a result of its low profile. To analyze this type of antenna, we use cavity model. As shown in the three-layer composition of this antenna, it is considered as a cavity surrounded by two layers of metal with imperfect electrical conductivity. As a result of leakage from the walls of this

antenna, radiation occurs from this cavity. For this reason, which is evident from the leakage of electromagnetic waves from the walls of this cavity, the antenna radiates the signals. One of the most important things to know how to find is the resonant frequency and radiation properties [6]. To find these things, we must first analyze the electromagnetic fields inside the cavities. In these cavities, the right side and the left side of it can be considered as perfect conductors while the surface and base of the cavity can be considered as imperfect conductors. We can find the amount of field propagation on the walls of the cavity by placing certain limits on these walls. The result of this analysis and knowing the amount of radiated fields within the walls of the cavities of this antenna enables us to calculate several important properties of the antenna, including the quality factor and the impedance of entry. Also, with the same results given from this analysis, the operating frequency and radiation characteristics can be found.

III. FEEDİNG TECHNİQUES

In general, when designing antennas, several important steps are passed, including choosing the frequency for which the antenna is to be designed, whether it is a receiver or transmitter, choosing the type of antenna, choosing the materials for which the antenna is to be designed; then it is designed on scientific bases and studied equations [1]. Then the type of feed for that antenna is selected. The patch antenna is no exception. It goes through the same steps. After calculating the appropriate dimensions and calculating the entry resistance, the type and dimensions of the appropriate feeding are calculated. The impedance of input to microwave and radio frequency systems should be equal to 50Ω, and 377Ω is considered as the air impedance [7]. The type, location and dimensions of the feed must be chosen in a way that ensures that it has impedance equal to 50Ω. Here the antenna is as a transducer. Feeding methods can be divided into two types. The first type is the connected and the second type is the unconnected. Connected feed methods consist of coaxial fed and Inset fed. Unconnected fed methods consist of proximity fed and Aperture fed [8].

A. Microstrip line feed

One of the simplest feeding methods used with the patch antenna is microstrip line fed. It is a type of conducting feeding techniques. In this technique, a long rectangular piece of metal is used of the same type of metal as the patch. Where, one end of this piece is connected to the patch and the other end to the port as shown in figure 1 [9]. This extra piece serves as a supply source for the patch antenna. The dimensions of the feed are calculated with the help of some equations used in microwave engineering, where must have dimensions that produce an impedance of 50 ohms. The dimensions of the patch antenna and the feed line are not the same, but there are many differences due to the entry impedance [8]. Where the width of the patch antenna is very large compared to the width of the feed line. One of the benefits of this feeding method is ease of manufacture. This type of feeding is attached to the insulator, and this is one of its benefits. Sometimes there are some antenna properties with undesirable values such as s11, gain, directivity, or radiation characteristics. Therefore, some parts of the antenna adjacent to the feed line are cut to obtain the desired values, as we have already said. By modifying these parts, we get a modified version of the feed line called inset fed line [9]. This method is mainly used to obtain matching impedance between the feed and the patch antenna, so when a match is obtained, the electromagnetic energy is completely transmitted to the patch antenna and all other parameters are improved [6]. This type of feeding is attached to the insulator, and this is one of its benefits. The disadvantage of this method is that as substrate thickness increases, surface wave and spurious feed radiation increases which limit the bandwidth. The spurious feed radiation and surface waves increase with the thickness of the dielectric substrate which hinders the antenna bandwidth [10]. The fed radiation results in unwanted polarized radiation. Narrow bandwidth and gain is one of the advantages patch antenna. The equivalent circuit of the line fed microstrip patch antenna is shown in the figure 2 [11].

B. Coaxial feed Technique

In this type of feeding, a coaxial cable is used to feed the antenna from the last layer. This technique is non-planar. The inner conductor is attached to the first layer (the patch) penetrating the insulating layer and the outer conductor to the third layer (ground plane) [12]. There is an advantage and disadvantage in using this type of feeding, as you can place the feed anywhere in order to agree to the input impedance, but this is not an easy matter. Another advantage is that the ground plane isolates unwanted radiation from the original radiation of the antenna, which enhances the performance. Another drawback of this technique is the difficulty of matching the insertion impedance on thicker substrates. The position of the feed is determined by the x- and y-coordinates when the impedances match at 50 ohms. The equivalent circuit of the Coaxial fed technique microstrip patch antenna is shown in the figure 4 [11].

C. Proximity feed

In this type of feeding technique, two pillars are placed between the two sides of the insulator. Since the impedance at the edges is very large, it is not possible to determine a specific point where the impedance matching occurs because it is very difficult. But there is a way to avoid this, by placing the substrate very close to the patch. The feed line is positioned at the edge so that the antenna impedance is 50 ohms. In this method, feeding is done by electromagnetic coupling between the pad and the feeding line. The radiation from the feed line will have a very less effect on the antenna because it is placed below the patch [13]. In this technology, the bandwidth is very wide compared to other technologies. For every technology there are drawbacks and the disadvantage of this technology is that it must be manufactured with multiple layers and poor polarization.

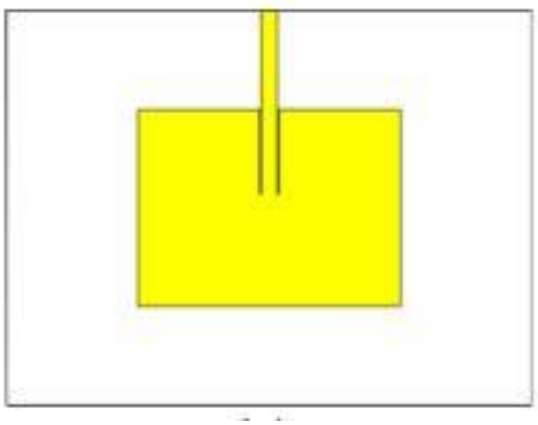

Fig. 1. Microstrip line fed

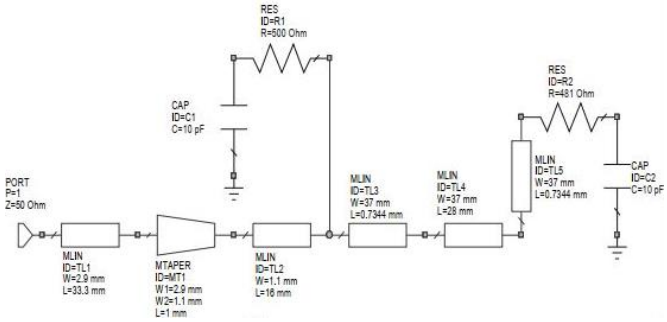

Fig. 2. Equivalent circuit of line fed microstrip patch antenna

Fig. 3. Coaxial cable feed

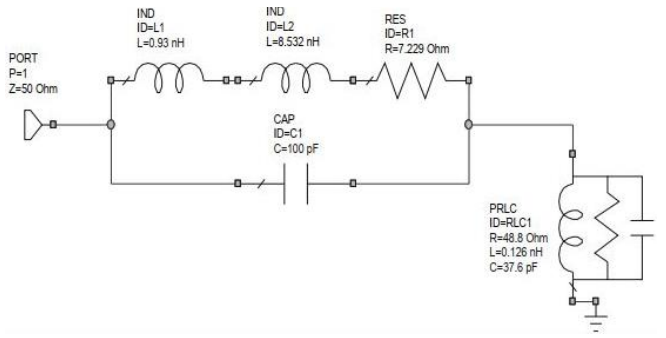

Fig. 4. Equivalent circuit of coaxial fed technique

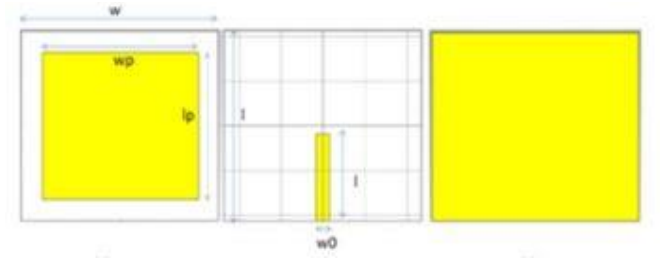

Fig. 5. Proximity feed

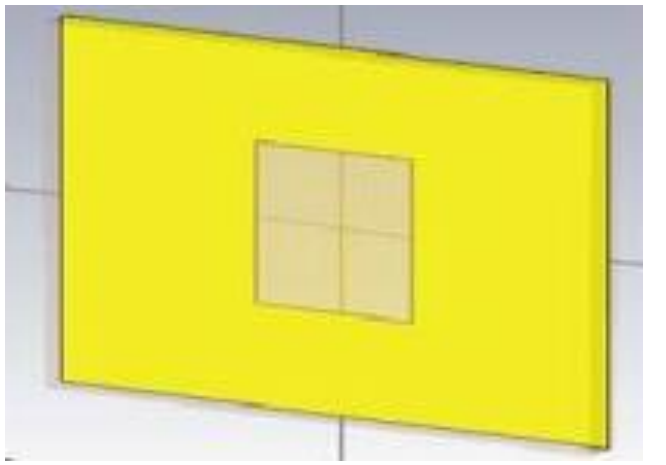

Fig. 6. Aperture feed

D. Aperture feed

This technology consists of two isolated holes, one of which is at the ground plane and the other below the antenna. These insulators are isolated by the third layer of the patch antenna (ground level) that has a hole in it [14]. The ground level is placed on the other side of the insulator. As for the second side of the insulator, both the feeding hole and the feeding insulator are placed. Where, the feed line and the ground level are placed on both sides of the insulator. The feeding line is perpendicular to the ground level hale. The energy taken from the feed line is coupled to the antenna patch through electromagnetic field coupling between them. One of the advantages of this method is to significantly improve feeding.

IV. Conclusion

In this study, an overview of the feeding techniques used with the patch antenna is presented. Some theoretical concepts related to antennas in general and the patch antenna in particular were also presented. The most important factors that can influence the choice of feed type were also discussed. The most commonly used feeding techniques by researchers and the research community was also discussed. The techniques discussed in this report include the following: microstrip line feed, Co-axial Feed, Aperture coupled Feed, and finally Proximity coupled Feed.

Contrubition of the Authors

The contributions of the authors to the article are equal.

Conflict of Interest

There is no conflict of interest between the authors.

Statement of Research and Publication Ethics

Research and publication ethics were observed in this study

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