# Micro strip Antennas

**Introduction**

The Microstrip Patch Antenna is a single-layer design which consists generally of four parts (patch, ground plane, substrate, and the feeding part). Patch antenna can be classified as single – element resonant antenna. Once the frequency is given, everything (such as radiation pattern input impedance, etc.) is fixed. The patch is a very thin ($t \ll \lambda_0$, where $\lambda_0$ is the free space wavelength) radiating metal strip (or array of strips) located on one side of a thin no conducting substrate, the ground plane is the same metal located on the other side of the substrate. The metallic patch is normally made of thin copper foil plated with a corrosion resistive metal, such as gold, tin, or nickel. Many shapes of patches are designed some are shown in figure (2.1) and the most popular shape is the rectangular and circular patch. The substrate layer thickness is 0.01–0.05 of free-space wavelength ($\lambda_o$). It is used primarily to provide proper spacing and mechanical support between the patch and its ground plane. It is also often used with high dielectric-constant material to load the patch and reduce its size. The substrate material should be low in insertion loss with a loss tangent of less than 0.005. In this work we have used Arlon AD 410 with dielectric constant of 4.1 and tangent loss of 0.003. Generally, substrate materials can be separated into three categories according to the dielectric constant $\varepsilon r$ [1].

1. Having a relative dielectric constant $\varepsilon r$ in the range of 1.0–2.0. This type of material can be air, polystyrene foam, or dielectric honeycomb.
2. Having $\varepsilon r$ in the range of 2.0–4.0 with material consisting mostly of fiberglass reinforced Teflon.
3. With an $\varepsilon r$ between 4 and 10. The material can consist of ceramic, quartz, or alumina.

The advantages of the microstrip antennas are small size, low profile, and lightweight, conformable to planar and non planar surfaces. It demands a very little volume of the structure when mounting. They are simple and cheap to manufacture using modern printed-circuit technology. However, patch antennas have disadvantages. The main disadvantages of the microstrip antennas are: low efficiency, narrow bandwidth of less than 5%, low RF power due to the small separation between the radiation patch and the ground plane(not suitable for high-power applications).

## 2.2. Types of Patch Antennas

There are a large number of shapes of microstrip patch antennas; they have been designed to match specific characteristics. Some of the common types are shown in figure (2.1), for millimeter wave frequencies, the most common types are rectangular, square, and circular patches.

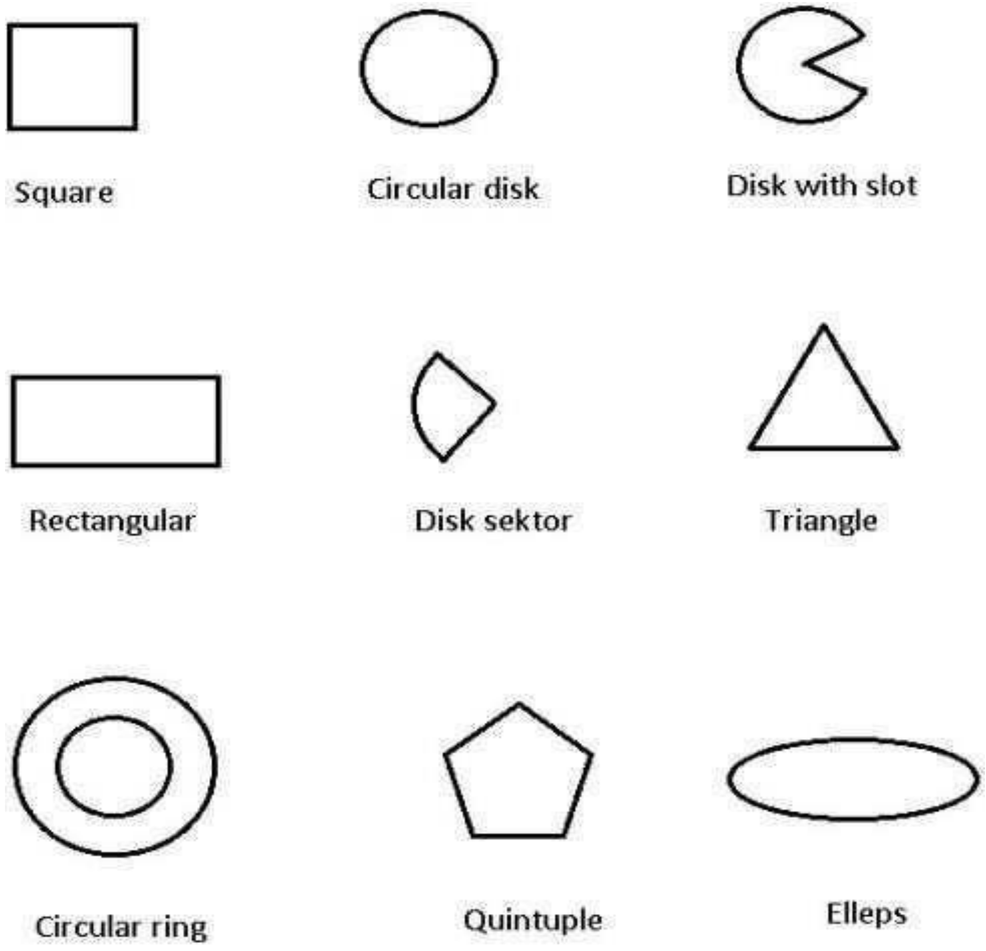


**Figure (2.1)** the most common shapes of patch antennas

Choose of substrate is also important, we have to consider the temperature, humanity, and other environmental ranges of operating. Thickness of the substrate $h$ has a big effect on the resonant frequency $fr$ and bandwidth $BW$ of the antenna. Bandwidth of the microstrip antenna will increase with increasing of substrate thickness $h$ but with limits, otherwise the antenna will stop resonating.

## 2.3. Feeding Methods

There are many methods of feeding a microstrip antenna. The most popular methods are:

1. Microstrip Line.
2. Coaxial Probe (coplanar feed).
3. Proximity Coupling.
4. Aperture Coupling.

Because of the antenna is radiating from one side of the substrate, so it is easy to feed it from the other side (the ground plane), or from the side of the element.

The most important thing to be considered is the maximum transfer of power (matching of the feed line with the input impedance of the antenna), this will be discussed later in the section of Impedance Matching.

Many good designs have been discarded because of their bad feeding. The designer can build an antenna with good characteristics and good radiation parameter and high efficiency but when feeding is bad, the total efficiency could be reduced to a low level which makes the whole system to be rejected.

### 2.3.1 Microstrip Line Feed.

This method of feeding is very widely used because it is very simple to design and analyze, and very easy to manufacture. Figure (2.2) shows a patch with microstrip line feed from the side of the patch.

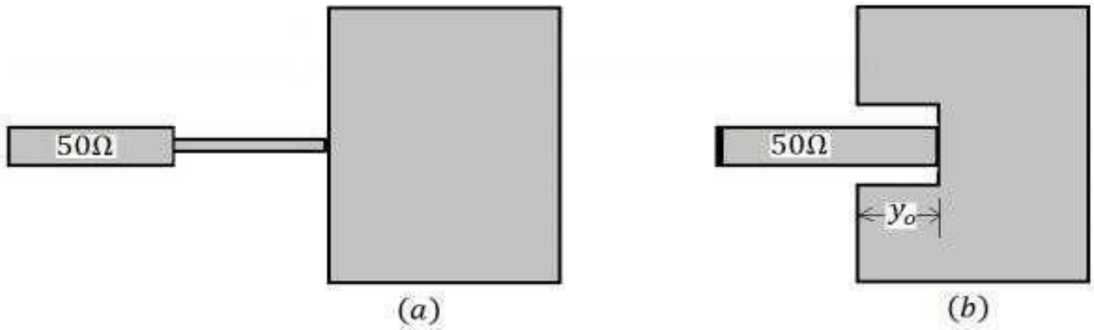


**Figure (2.2)** Microstrip patch antenna with feed from side

The position of the feed point ($y_o$) of the patch in figure (2.2b) has been discussed in details in the section of Impedance Matching.

Feeding technique of the patch in figure (2.2a) and figure (2.3) is discussed in [7]. It is widely used in both one patch antenna and multi-patches (array) antennas.

The impedance of the patch is given by [7]:

$$Z_a = 90\frac{\varepsilon r^2}{\varepsilon r-1}\left(\frac{L}{W}\right)^2 \qquad (2.1)$$

The characteristic impedance of the transition section should be:

$$Z_T = \sqrt{50 + Z_a} \qquad (2.2)$$

The width of the transition line is calculated from [7]:

$$Z_T = \frac{60}{\sqrt{\varepsilon_r}} ln(\frac{8d}{W_T} + \frac{W_T}{4d}) \qquad (2.3)$$

The width of the $50\Omega$ microstrip feed can be found using the equation (2.4) below:

$$Z_o = \frac{120\pi}{\sqrt{\varepsilon reff}\left(1.393+\frac{W}{h}+\frac{2}{3}\ln\left(\frac{W}{h}+1.444\right)\right)} \qquad (2.4)$$

Where $Z_o = 50\Omega$

The length of the strip can be found from (4.24)

$$R_{in(x=0)} = cos^2(\frac{\pi}{L}x_o) \qquad (2.5)$$

The length of the transition line is quarter the wavelength:

$$l = \frac{\lambda}{4} = \frac{\lambda_o}{4\sqrt{\varepsilon_{reff}}} \qquad (2.6)$$

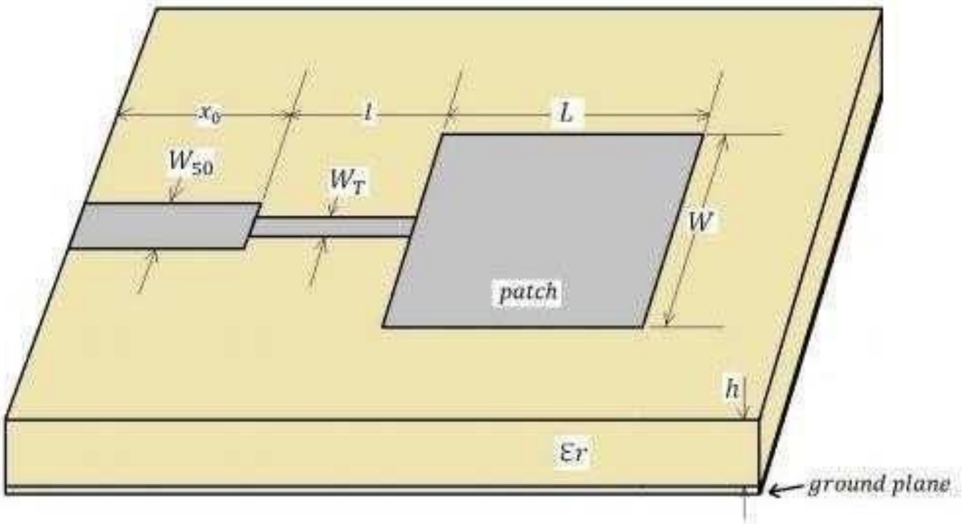


**Figure (2.3)** Rectangular microstrip patch antenna