# DESIGN AND DEVELOPMENT OF MICROSTRIP PATCH ANTENNA FOR GSM APPLICATION

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**This report is submitted in partial fulfilment of the requirement for the award of Bachelor of Electronic Engineering (Wireless Communication) With Honors**

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## DECLARATION

I hereby declare that this report entitled "Design and Development of Microstrip Patch Antenna for GSM Application" is the result of my own work and that, to the best of my knowledge and believe. It contains no material previously published or written by another person except for quotes as cited in the references and also no material which to a substantial has been submitted for the award of any other degree or diploma of a university or other institution of higher learning.

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"I hereby declare that I have read through this report entitled "Design and Development of Microstrip Antenna for GSM Application" and found that it is sufficient to a comply the partial fulfilment for awarding the degree of Bachelor of Electronics Engineering (Telecommunication Engineering) with Honours"

Signature: ……

Supervisor: En. Imran bin Mohd Ibrahim

Date: 15 / 06 / 2016

# DEDICATION

**Special to my beloved mother and father who always standby my side in giving supports morally and physically**

## ACKNOWLEDGEMENT

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# ABSTRACT

In microstrip patch of short-range communication system, an antenna is very important part that used to enhance and strength the signals. However, in many cases of short-range communication system, the gain of the designed antenna that used is quite low so that it results in low power and affect the target frequency to transmit and receive signal in well condition. This project aims to design an antenna that provides a high gain so that the transmitted signal and efficiency of radiating the signal would be increased. A small microstrip patch antenna is designed in CST Studio Suite software. Optimization in CST software for the microstrip antenna designed is done prior to fabrication process that is carried in the laboratory. Once the simulation and fabrication processes are done, comparison of the antennas performance is carried, in terms of antenna parameters such as gain, return loss, bandwidth, efficiency and radiation pattern.

The microstrip antenna is designed for GSM and short-range communication applications operating at frequency of 868 MHz with return loss less than -10 dB and wide bandwidth between 800-900 MHz. the produced antenna can be come up with short-range communication system that can be used to power the low power devices such as mobile phones and wireless sensors used under the sea so that batteries do not have to be replaced frequently which will save environment of batteries waste and save a lot of money spent for replacing the low power devices batteries as well.

# ABSTRAK

Dalam mikrostrip patch sistem komunikasi jarak dekat, antena adalah bahagian yang sangat penting yang digunakan untuk meningkatkan dan kekuatan isyarat. Walau bagaimanapun, dalam banyak kes sistem komunikasi jarak dekat, gandaan antena direka yang digunakan adalah agak rendah supaya menghasilkan tenaga yang rendah dan menjejaskan kekerapan sasaran untuk menghantar dan menerima isyarat dalam keadaan baik. Projek ini bertujuan untuk mereka bentuk antena yang menyediakan keuntungan yang tinggi supaya isyarat dan kecekapan terpancar isyarat yang dipancarkan akan meningkat. A kecil antena mikrostrip patch direka dalam perisian CST Studio Suite. Optimization dalam perisian CST untuk antena mikrostrip yang direka dilakukan sebelum proses fabrikasi yang dijalankan di makmal. Setelah proses simulasi dan fabrikasi selesai, perbandingan prestasi antena itu dijalankan, dari segi parameter antena seperti keuntungan, kehilangan pulangan, jalur lebar, kecekapan dan corak radiasi.

The mikrostrip antena direka untuk aplikasi GSM dan komunikasi jarak dekat yang beroperasi pada frekuensi 868 MHz dengan kehilangan pulangan kurang daripada -10 dB dan lebar jalur luas antara 800-900 MHz. antena yang dihasilkan boleh datang dengan sistem komunikasi jarak dekat yang boleh digunakan untuk kuasa peranti kuasa rendah seperti telefon bimbit dan sensor tanpa wayar yang digunakan di bawah laut, sehingga bateri tidak perlu digantikan kerap yang akan menyelamatkan alam sekitar bateri membuang dan menjimatkan banyak wang yang dibelanjakan untuk menggantikan peranti kuasa rendah bateri juga.

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# CHAPTER 1

# INTRODUCTION

## 1.1 Background

Wireless communication technology has become more important to everybody in day life. There are two main parts in wireless communication which are physical part and the application system. As we know that the antenna is from the important components in the system of physical to convert the electrical energy into the air for signal transmission. From the properties of microstrip antenna are small size, , low profile, low-cost fabrication, conformability, lightweight, ease of installation and integration with feed networks and one of the serious limitations of these antennas are narrow bandwidth. So it can be seen that the characteristics as it limits the frequency ranges over which the antenna can perform well [2]. The emergence of technical improvements has enabled a large number of new services. The improvement of such these technical has many features to develop the world utilities such the wide used application GSM and CDMA. For supporting such application which requires the speed internet connection, high definition video, and other application, there should need high data rate.

In modern wireless of communication system with the increasing of other wireless applications that requires low cost and high performance multiband antennas, this demand a high performance in multi-standard communication systems that led the antenna research and studies in many directions. On of this design of multiband microstrip antenna is Global system of mobile communication (GSM).

Transmission line of microstrip in dielectric thickness is as follow;

| | | | |
|---|---|---|---|
| Dielectric constant | $\varepsilon_r$ | 4 | |
| Height of dielectric layer | h | 15 | cm |

| | | | |
|---|---|---|---|
| Width of signal line | w | 7.5 | mm |
| Thickness of signal line | t | 1.6 | mm |

In the designed parameters we have obtained the initial results for VSWR which is 2:1 for 5.8 and 2:1 for 26, for the percent bandwidth is 11.5 %, minimum gain = -6db, radiation pattern which we are going to plot it by using SCT software and we got the return loss which is less than 10 dBi [1].

$$\Delta W = t\left(\frac{1+1/\varepsilon r}{2\pi}\right) ln\left[\frac{10.82}{\sqrt{\left(\frac{t}{h}\right)^2+\left(\frac{1/\pi}{\frac{W}{t}+1.1}\right)^2}}\right] \quad (2.1)$$

$$w' = w + \Delta w \quad (2.2)$$

From the equation above; we can analyze that the transmission line, Characteristic impedance and Effective relative permittivity can be increased if the corresponding bandwidth or the SNR (also defined as transmission power). However, the transmission power cannot easily increase since there are some devices such as portable devices are battery poweredand also potential interference can be avoided. Hence, in order achieve the greater data rate, we need to increase the bandwidth. In addition to telephony, services for digital fax and data transmission were already defined back when GSM standards were created. Apart of pure voice transmission, GSM specifications, for example, providing a broad diversified spectrum of data services and fax. Furthermore, the first data services in GSM networks were circuit-switched, asynchronous data services (CSD, Circuit Switched Data), as those long used for remote data transmission in analog telephone networks. Only specific, international, standardized communication protocols are used for dial-up and transmitting data. Therefore, data can be exchanged with all conventional receivers, provided that the devices used comply with these international applicable standards

During the early 1980s, analog cellular telephone systems were experiencing rapid growth in Europe, particularly in Scandinavia and the United Kingdom, but also in France and Germany. Each country developed its own system, which was incompatible with everyone else's in equipment and operation. This was an undesirable situation, because not only was the mobile equipment limited to operation within national boundaries, which in a

unified Europe were increasingly unimportant, but there was also a very limited market for each type of equipment, so economies of scale and the subsequent savings could not be realized. However, there are necessary for developers as well as engineers to design a system that has capacity to support and handle the larger bandwidth. One of the components of this system is antenna which is considered as most important design element. If the antenna isn't well designed, then there will be degradation in the data signal before it even reaches the end users. Due to this reason, engineers are done many researches on design an antenna that will compatible with GSM application. There are many types of antenna that can be applied in order to achieve the GSM antenna, however in this project, we focusing on the microstrip patch antenna. Microstrip patch antenna becomes very popular in any antenna design nowadays since its ease of fabrication, planar design, mechanical reliability and mass production [4, 5]. The advantages of microstrip antennas are that they are low-cost, conformable, lightweight and low profile, while both linear and circular polarization is easily achieved. These attributes are desirable when considering antennas for wireless system [1].

From the objectives of this project are design a global system for mobile (GSM) antenna for communication that can produce larger bandwidth between the ranges of frequency of 800MHz to 900 MHz. In order to design a global system for mobile antenna there are many parameters need to be considered. The parameters are dielectric constant, r, length, L and width, W of the patch antenna, feeding technique, the ground size and so on. Therefore, a suitable technique is required in order to designing an antenna that can produce GSM. In this project, by modifying the shape and dimensions of conventional microstrip antennas will be studied and we will use FR4 for a fabrication board, and we will design a single band microstrip antenna for GSM system by tuning the shape and dimensions.

## 1.2 Problem Statement

Modern wireless in communication systems with increasing of other wireless applications have become the most technology revolution in the world. These require low cost and high performance multiband antennas. The demand for high performance multi-standard communication systems has led the antenna research and studies in various

directions; one of these studies is the design of multiband micro-strip patch antennas. Systems such as Global System for Mobile Communications (GSM) and global position system (GPS) are required to operate at two different frequencies apart too far from each other. In addition, Micro-strip antennas can avoid the use of two different single band antennas.

Furthermore, the main disadvantages and limitations of the microstrip antenna are the narrow bandwidth and the low gain (~ 6 dB). Therefore, one of the serious limitation of microstrip antennas is the narrow bandwidth characteristic, being 15% to 50% that of commonly used antenna elements such as dipoles, array and slots. The use of microstrip patch antenna is no longer suitable because of its characteristic that has narrow bandwidth and low gain. However, the main problem in this project is to achieve 1MHz bandwidth with center frequency of 868MHz with small size but has good performance.

## 1.3 Objectives

The objectives of this project are as follows:

i. To design microstrip patch antenna for GSM application at operating frequency of 868 MHz
ii. To Simulate and fabricate the antenna design.
iii. To validate the obtained simulation results through the experiment results

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 Introduction

GSM (Global System for Mobile communications) is very common, its including in digital cellular technology that can be used for transmitting mobile voice and data services. GSM is different with first generation wireless systems in the usage of digital technology. GSM system can cover the frequency range from 800 to 900 MHz in this new design based on the parameters given, which can be seen its from narrow pulses to transmit data at low gain. With such large bandwidth of 11.5 %, it offers specific advantages to the communication technologies especially in term capacity of channels, data transfer rate and so on. In last few years, the development and applications of GSM has a lot of influences in the communication technology; hence the interest has growth exponentially. In this chapter it has been briefed about the GSM application for mircostrip patch antenna.

## 2.2 GSM Technology (Global System in Mobile Communication)

Global system in mobile communication is defined as the digital mobile telephony system that is widely used in many countries and it becomes popular over world. GSM is used variation of time division multiple access. The GSM network technology can be divided into three broad parts such as:

i. The subscriber carrier the mobile station
ii. The base station subsystem that controls the radio link with mobile station
iii. The network subsystem performs the switching of calls between the mobile users and many others mobiles and fixed network users

### 2.2.1 Historical Background

Even though the global system in mobile communication (GSM) technology is the revolutionary of the wireless communication system, yet it is not the new concept. Developed after revolution in Electronic Circuit Miniaturization & LSI in 1970.Used on rockets & missiles previously and Designer's choice. Although in the past, the first cellular telecommunications systems represented a huge conversion in capabilities. The first cell phone systems that were advanced used analogue technology. Typically, they used frequency-modulated carriers for the voice channels and data were carried on a separate shared control channel. Two major systems that were in existence were the AMPS (Advanced Mobile Phone System) [12].

In the USA and many other countries and TACS were used (Total Access Communications System) and in the UK as well as many other countries around the world. Also there is another system that was completed and achieved the milestone of being the first system to be commercially deployed; this system is the Nordic Mobile Telephone system (NMT). This system was developed by a consortium of companies in Scandinavia and proved that international cooperation was possible. The success of these systems proved to be their downfall. The installed systems that used around the globe increased significantly and the effects of the limited frequency allocations were soon noticed. To overcome these number of actions that were taken. This system known as E-TACS or Extended-TACS was introduced to give the TACS system further channels. In the USA another system known as Narrowband AMPS (NAMPS) was developed [4].

### 2.2.2 Microstrip Antennas Requirement

While the commercialization of the GSM spectrum, it was like a shot to all the developers and engineers to develop such antenna that can use for GSM. All of the fundamental parameters of an antenna must be considered in designing antennas for any applications of large bandwidth. However, there are additional challenges for GSM. Such as GSM antenna must be operating over the entire 868 MHz frequency range and GSM antenna

must achieve almost impedance bandwidth about 900 MHz. Radiation pattern and radiation efficiency these are one of the significant characteristics that must be taken into account to complete the antenna design. A nearly omni-directional radiation pattern is desirable in that, it can ease in the receiver and transmitter location. This shows maximizing the half power beamwidth and minimizing directivity and gain. Conductor and dielectric losses should be minimized in order to enlarge the radiation efficiency, while the Low loss dielectric used to maximize radiation efficiency. The high radiation efficiency is imperative for GSM antenna because the transmit power spectral density is excessively low. Therefore, any excessive losses happened by the antenna, it could potentially compromise the functionality of the system. The primary application focuses on integrated circuits for portable electronic applications. Therefore, the antenna is required to be physically compact and low profile, preferably planar. In our projects, it has been evaluated and presented several topologies, considering effect between each design.

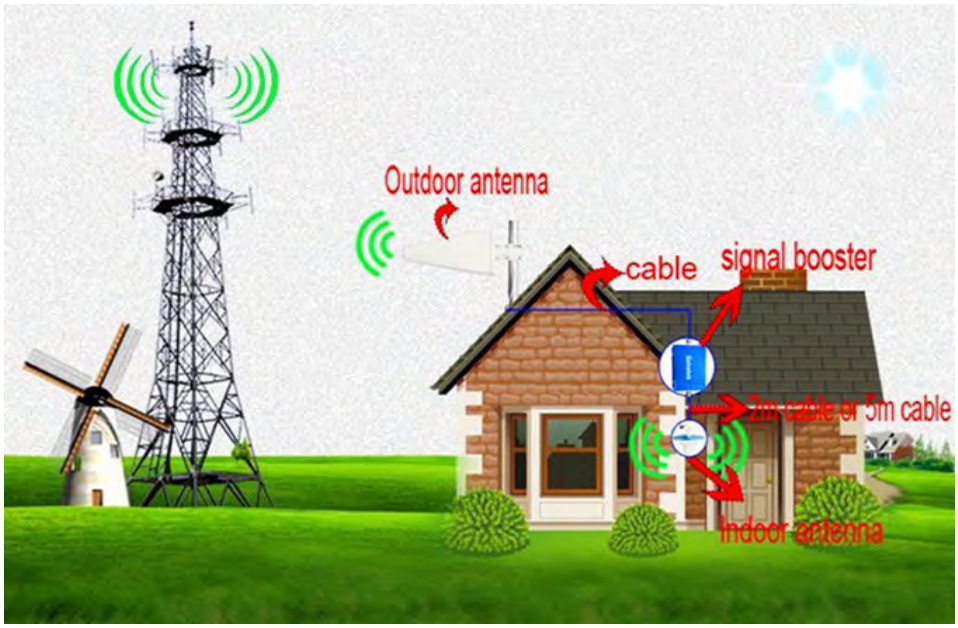


Figure 2.1: The system topology of GSM

### 2.2.3 GSM Advantages

There are several advantages of the GSM that are the reasons why it presents a better solution to wireless broadband than other technologies. First of all, as we know there are

many information about GSM (global system of mobile) which we can gain knowledge from, so we can now tell some of advantages of GSM:

i. A large number of calls can be made from a single tower, as it divides the frequency of the bands into many channels. Due to its features, it is widely accepted and covers 82% of the global market. So, GSM works on the basis of Time division multiple access (TDMA) which allots a specific time period at specific frequency to the GSM.
ii. GSM competes primarily with Code Division Multiple Access technology. Global System for Mobiles is the primary technology used globally for 3G mobile networks, with about a 73 percent market share.
iii. GSM can provide compatibility, multitasking and speed advantages over CDMA on a 3G network.

### 2.2.4 Disadvantages of GSM

i. GSM can share multiple users with the same bandwidth, with enough users, the transmission can encounter interference. Therefore, 3G have been developed on different types of networks than GSM to overcome this reason.
ii. GSM can interfere with certain electronics, such as pace makers and hearing aids, this interference happens due to the fact that GSM uses a pulse-transmission technology.
iii. High gain and large bandwidth.

### 2.2.5 Spectrum of Frequency

While the majority of GSM activity falls into just a few bands, for some specialist applications, or in countries where spectrum allocation requirements mean that the standard bands cannot be used, different allocations may be required. Accordingly, for most global roaming dual band, tri-band or quad-band phones will operate in most countries, although in some instances phones using other frequencies may be required.

GSM has the compatibility which is from the speed advantage. In addition, the GSM of microstrip patch antenna consists of a radiating patch on one of side of dielectric substrate which has a ground plane on the other side. For good antenna performance, a thick dielectric substrate has a low dielectric constant which is desirable since this provide better efficiency, better radiation and larger bandwidth. Interference in only part of the spectrum reduces the amount of received signal, but the pulse still can be recovered to restore the signal. Hence GSM is perhaps the most secure means of wireless transmission ever previously available [11].

Researchers and engineers are working to develop the GSM technology in the near future. With such advantages, the electronics user may able enjoying the technology of GSM and advanced the technology of communication. We can show some advantages and benefits of GSM system.

Table 2.1: The advantages and benefits of GSM

| **Advantage** | **Benefits** |
|---|---|
| Large channel capacity | High bandwidth can support real-time high-definition Video streaming. |
| Coexistence with current | Avoids expensive licensing fees. |
| narrowband | Avoids expensive licensing fees. |
| and wideband radio services | Avoids expensive licensing fees. |
| Ability to work with low SNRs | Offers high performance in noisy environments. |
| Low transmit power | Provides high degree of security with low probability of Detection and intercept. |
| High performance in multipath channels | Delivers higher signal strengths in adverse conditions. |

### 2.2.6 Global System of Mobile Applications

Fundamentally, from the Shannon-Hartley theorem, the GSM provides high data rates using very low power at very limited range, which will lead to the applications well suited for wireless personal area network (WPAN). These advantages provide GSM to be a circuit-switched system that divides each 200kHz channel into eight 25kHz time-slots. GSM operates in the 900MHz and 1.8GHz bands in Europe and the 1.9GHz and 850MHz bands in the US. The 850MHz band is also used for GSM and 3GSM in Australia, Canada and many South American countries. GSM supports data transfer speeds of up to 9.6 kbit/s, allowing the transmission of basic data services such as SMS (Short Message Service). Another major benefit is its international roaming capability, allowing users to access the same services when travelling abroad as at home [3].

Secondly, GSM technology can be entered in -Digital Communication such GPS, Cell Phones, Laptops. And Mobile Station The mobile station (MS) consists of the mobile equipment (the terminal) and a smart card called the Subscriber Identity Module (SIM). The SIM provides personal mobility, so that the user can have access to subscribed services irrespective of a specific terminal.in addition, High data rate of GSM systems are capable of gathering and disseminating or exchanging a vast quantity of sensory data in a timely manner. The cost of installation and maintenance can drop significantly by using GSM sensor networks due to being free from wires. This advantage is especially attractive in medical applications because GSM sensor network frees the patient from wires and cables when extensive medical monitoring is required. Furthermore, with a wireless solution, the coverage can be expanded more easily and made more reliable [3].

Positioning and tracking is another unique property of GSM. Since GSM has the high data rate characteristic in large frequency range, GSM provides an excellent solution for indoor location with a much higher degree of accuracy than a Global Positioning Systems (GPS). In addition, with advanced tracking mechanism, the precise determination of the tracking of moving objects within an indoor environment can be achieved with an accuracy of several centimeters.GSM systems can operate in complex situations to yield faster and more effective communication between people. It can be used to find people or objects in a case of calamities, such as casualties in children lost in the mall, lost people in natural disaster such as earthquake, fire fighters in a burning building and so on.

Lastly, GSM can also be applied to radar and imaging applications. It has been used in military applications to locate enemy objects behind walls and around corners in the battlefield. It has also found value in commercial use, such as rescue work where GSM radar could detect a person's breath beneath rubble, or medical diagnostics where X-ray systems may be less desirable.

Due to wide applicable of the GSM systems motivate most of the developers and engineers to improve the systems in near future, by making it useful for the further long distance usage as well. Recently developers such as Motorola and Intel has step into optimizing the usage of GSM technology in our daily life by providing high speed, short-range wireless personal area connectivity for PCs and mobile devices [3].

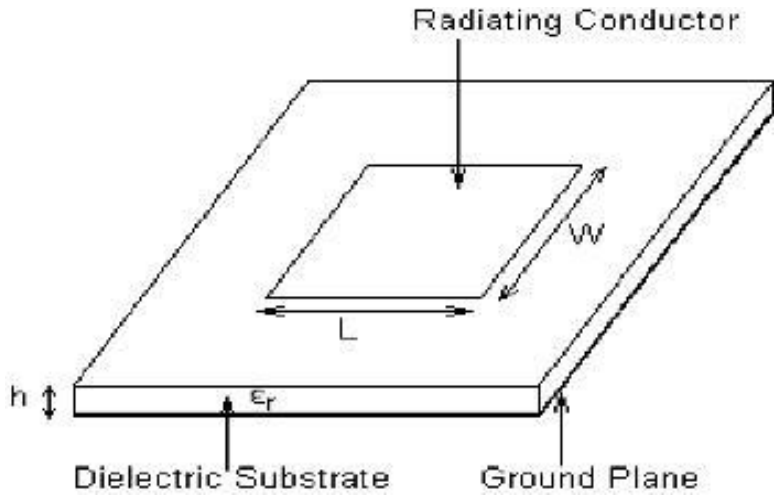


Figure 2.2: A Typical Microstrip Antenna

## 2.3 Selection of Antenna for GSM Antenna

As mentioned previously, many different types of antennas are currently being considered for GSM applications. Among these antenna configurations, microstrip antennas feature simple structure, easy fabrication, wide frequency bandwidth and satisfactory radiation patterns. Hence, as for the Project I, we would design GSM antenna using micro-strip line patch antenna. As shown in figure above, a micorstrip antenna in its simplest configuration consists of a radiating patch on one side of a dielectric material (r<10), which has a ground plane on the other side. The patch conductors, normally of copper or gold, can assume virtually any shape, but regular shapes are generally used to simplify analysis and

performance prediction. Ideally, the dielectric substrate should be low (r 2.5), to enhance the fringe field that account for radiation However, other performance requirements may need to use dielectric constant whose dielectric constant greater than the above mentioned value.

Microstrip antennas are characterized by a larger number of physical parameters than are conventional microwave antennas. They can be designed to have many dimensions and shapes.

All microstrip antennas can be divided into four categories: microstrip patch antennas, microstrip dipoles, printed slot antennas, and microstrip traveling wave antennas.

### 2.4.1 Microstrip Patch Antennas

A large number of patch microstrip antennas have been studied and used up to date. The rectangular and circular patches are the basic and most commonly used microstrip antennas. These patches can be used for the simplest and the most demanding applications. For instance, characteristics such as dual and circular polarizations, dual frequency operations, frequency agility, broad bandwidth, feed line flexibility, omni-directional pattern and so on are easily to achieve. Moreover, Patch antenna are popular for their well-known attractive features, such as low profile, light weight and compatibility with Microwave Integrated Circuit (MIC) and Monolithic Microwave Integrated Circuit (MMIC).

A microstrip patch antenna consists of a conducting patch of any planar or non-planar geometry on one side of a dielectric substrate with a ground plane on other side. Typically a patch antenna has a gain between 5 and 6 dB. Furthermore, as shown in figure the antenna patches can have several shapes, while the most used patches shapes are circular, square and rectangular [11].

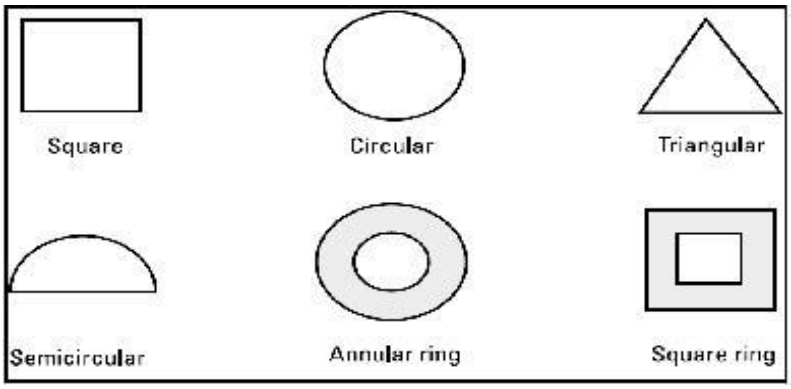


Figure 2.3: Basic Microstrip Patch Antenna Shapes Commonly Used In Practice.