Dual Band Microstrip Patch Antenna For WiMAX and WLAN Application : A Review

Markad Akshay R.[1]
M.E. Scholar Department of E&TC
MSSCET, Jalna,
Maharashtra, India.
akshay.markad2@gmail.com

A. S. Patel[2]
Asst. Professor Department of E&TC
MSSCET, Jalna,
Maharashtra, India.
atmeshpatel@gmail.com

***Abstract*— A Microstrip patch antenna has become a popular in research area. In which dual band and multiband have more advantage and better prospects in Wireless communication system. There are two important standards Wireless Local Area Networks (WLAN) and Worldwide Interoperability for Microwave Access (WiMAX) have been widely applied in mobile devices such as handheld computers and smart phones etc. Both are flexible, Reliable, cost effective, high speed data connectivity and gives mobility to user. This paper based on the literature survey of different types of radiating patches, feeding techniques and different substrate for dual band Microstrip antenna(MSA) for WLAN and WiMAX application. Also we discuss the basics of Microstrip antenna, different parameters of antenna, different feeding techniques, design model, measuring parameters, advantages and disadvantages of radiating patch antenna.**

Keywords—*MSA, WLAN, WiMAX, feeding.*

I. INTRODUCTION

In this era of next generation networks we require high data rate and size of devices are getting smaller day by day. Antenna is defined as a device or a transducer which transforms an RF signal into electromagnetic waves and acts as a means to transmit and receive radio waves. In reception, an antenna intercepts some of the power of an electromagnetic wave in order to produce a tiny voltage at its terminals that is applied to a receiver to be amplified. Antennas are essential components of all equipment that uses radio. Microstrip antennas have gained a lot of popularity due to their salient features such as low profile, simple and inexpensive to design and manufacture, flexible in terms of configuration, polarization, pattern, resonant frequency and impedance when a particular shape and mode are selected. These antennas are used in various applications for example, in satellite communication [3], in handsets and base stations for mobile communication, in telemetry antennas for missiles and so on. Microstrip antennas cover a broad frequency spectrum from 100 MHz to 100 GHz, thus possess several advantages as compared to conventional antennas. A microstrip antenna consists of a conducting patch of any geometry on a ground plane and separated by a dielectric substrate. The rectangular and circular patches are most common geometry used in microstrip antenna. Rectangular patches (Fig.1 (a)) is chosen as they are very simple to analyze and [3] circular patches (Fig.1 (b)) is chosen due to their symmetric radiation pattern. Low dielectric constant substrates are generally preferred for maximum radiation.

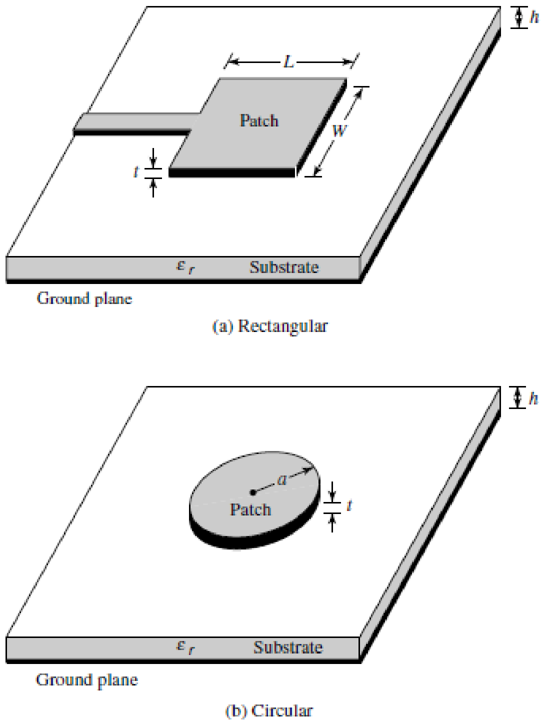

Fig. 1. Structure of Microstrip Patch Antenna

The dielectric substrates used are Bakelite, FR4 Glass Epoxy, RO4003, Taconic TLC and RT Duroid. The height of the substrates is constant i.e., h=1.6 mm. Some properties of different substrate are explained in Table1. Dielectric constant for the better performance of microstrip antenna should as low as possible. The proposed dual band microstrip antenna specially for WLAN application is printed on a FR-4 substrate [1]. The dielectric substrate is a material which separate the ground plane and radiating patch to avoid interference and mutual fields. To minimize the cost and dimension of microstrip antenna each element share the common ground plane. This will allow all elements to be fabricated on a single dielectric sheet. Some properties substrates are explained in Table1.

TABLE I. PROPERTIES OF DIFFERENT SUBSTRATE FOR MICROSTRIP PATCH ANTENNA DESIGN

Parameter	Bakelite	FR4	RO4003	Taconic	RT Duriod
Dielectric Constant	4.78	4.36	3.4	3.2	2.2
Water Absorption	0.5-1.3%	<0.25%	0.06%	<0.02%	0.02%
Loss Tangent	0.03045	0.013	0.002	0.002	0.0004
Tensile strength	60MPa	<310M Pa	141MPa	-	450MPa
Breakdown Voltage	20-28kv	55kv	-	-	>60kv
Peel Strength	-	9 N/nm	1.05 N/nm	12 N/nm	5.5 N/nm
Density	1810 kg/m^3	1850 kg/m^3	1790 kg/m^3	-	2200 kg/m^3
Surface Resistivity	$5x10^{10}$ Mohm	$2x10^5$ Mohm	$4.2x10^9$ Mohm	$1x10^7$ Mohm	$3x10^7$ Mohm
Volume Resistiity	$3x101^{15}$ Mohmcm	$8x10^7$ Mohmcm	$1700x10^7$ Mohmcm	$1x10^7$ Mohmcm	$2x10^7$ Mohmcm

II. LITERATURE SURVEY

A simple printed dual-band double-T monopole antenna is proposed by Yen-Liang Kuo and Kin-Lu Wong. The antenna comprises two stacked T-shaped monopoles of different sizes, which generate two separate resonant modes for the desired dual-band operations. The proposed antenna has a low profile and can easily be fed by using a 50Ω microstrip line. Prototypes of the proposed antenna designed for WLAN operations in the 2.4 and 5.2 GHz bands have been constructed and tested. Good radiation characteristics of the proposed antenna have been obtained. Effects of varying the monopole dimensions and the ground-plane size on the antenna performance have also been studied. The T- shaped monopoles is printed on the same side of the dielectric substrate (FR4 substrate of thickness 1.6 mm and relative permittivity 4.4 was used.) [1]. On the other side of the dielectric substrate, a ground plane of length and width is printed below the patch.

A wideband dual layer rectangular U-Slot patch antenna for WiMAX and WLAN applications is proposed by M. A. Matin, M. P. Saha and H. M. Hasan. The antenna exhibits wideband characteristics that depend on various parameters such as U-slot dimensions, circular probe-fed patch etc. The characteristics of the proposed antenna are calculated and compared with other designs. The antenna shows 36.2% impedance bandwidth with more than 90% antenna efficiency and is best suited for 2.3/2.5 GHz WiMAX and 2.4 GHz WLAN applications. The proposed U-slot wideband patch antenna has a circular coaxial probe-fed patch configuration, based on the conventional patch antenna. A coaxial probe is connected to the circular feeding patch which is located close to rectangular U-slot patch centre for good excitation of the proposed antenna [2] over a wide bandwidth.

A compact microstrip fed dual-band coplanar antenna for wireless local area network is presented by Rohith K. Raj, Manoj Joseph, C. K. Aanandan, K. Vasudevan and P. Mohanan. The antenna comprises of a rectangular center strip and two lateral strips printed on a dielectric substrate and excited using a 50 Ω microstrip transmission line. The antenna generates two separate resonant modes to cover 2.4/5.2/5.8 GHz WLAN bands. Lower resonant mode of the antenna has an impedance bandwidth (2:1 VSWR) of 330 MHz (2190–2520 MHz), which easily covers the required bandwidth of the 2.4 GHz WLAN, and the upper resonant mode has a bandwidth of 1.23 GHz (4849–6070 MHz), covering 5.2/5.8 GHz WLAN bands. The proposed antenna occupy an area of 217 mm^2 when printed on FR4 substrate [4] ($\varepsilon_r = 4.7$).

A Single Layer Dual band Microstrip Patch Antenna using single U-slot is proposed by Tej Raj and Brajlata Chauhan. This broadband patch antenna [3] is simulated and broadband operation is achieved and then additional u-shaped slot is introduced to create the additional notch frequencies which turn into multiple band patch antenna [6]. First with a single u-slot is cut in the patch leads to broadband operation is achieved and then additional u slot of proper dimensions is cut into the patch which generates additional band notch at a frequency in the original broadband. Thus dual band antenna is become from the broadband. Advantage of such configuration is that the complexity is reduced, simple feed and single patch is used. The proposed antenna has a low profile and can easily be fed by using a probe feeding technique [5].

III. PARAMETERS

Some basic antenna parameters [3] such as Antenna Gain, VSWR, Radiation Pattern, Radiation Intensity, Return Loss, Beamwidth, Directivity, Effective Aperture, Antenna Efficiency, Bandwidth and Input Impedance etc. are studied.

A. Antenna Gain (G)

The gain of an antenna is defined as the ratio of the intensity, in a given direction, to the radiation intensity that would be obtained if the power accepted by the antenna were radiated isotropically.

$$G=4\pi * U(\theta, \Phi) /Pin$$

Where, U (θ, Φ) is radiation intensity in a given direction, Pin is total input power.

B. VSWR

Voltage standing wave ratio is defined as

$$VSWR=V_{max} / V_{min}.$$

It should lie between 1 and 2.

C. Beamwidth

The beamwidth of a power pattern is defined as the angular separation between two identical points on opposite side of the pattern maximum.

D. Radiation Pattern

The radiation pattern is defined as a mathematical function or a graphical representation of the radiation properties of the antenna as a function of space coordinates. The Pattern is three dimensional figure plotted on (x, y, z) axis, in which we have major lobe, minor lobe, side lobe, back lobe, first null beamwidth (FNBW), half power beamwidth (HPBW).

E. Radiation Intensity (U)

Radiation intensity in a given direction is defined as "the power radiated from an antenna per unit solid angle." The radiation intensity is a far-field parameter, and it can be obtained by simply multiplying the radiation density by the square of the distance. In mathematical form it is expressed as

$$U = r^2 * W_{rad} \text{ (W/unit solid angle)}$$

Where, U = Radiation Intensity

W_{rad} = Radiation Density

r = distance

F. Return Loss (RL)

Return loss is the reflection of signal power from the insertion of a device in a transmission line. Hence the RL is a parameter similar to the VSWR to indicate how well the matching between the transmitter and antenna has taken place. The RL is given as by as:

$$RL = -20 \log10 (\Gamma) \text{ dB}$$

For perfect matching between the transmitter and the antenna, $\Gamma = 0$ and $RL = \infty$ which means no power would be reflected back, whereas a $\Gamma = 1$ has a $RL = 0$ dB, which implies that all incident power is reflected. For practical applications, a VSWR of 2 is acceptable, since this corresponds to a RL of -9.54 dB.

G. Directivity (D)

Directivity of an antenna defined as "the ratio of the radiation intensity in a given direction from the antenna to the radiation intensity averaged over all directions".

$$D = U / U_0 = 4\pi * U / P_{rad}$$

Where, U = Radiation Intensity

U_0 = Radiation Intensity of Isotropic Source

P_{rad} = Total Radiated power.

H. Antenna Efficiency (e_0)

It is a ratio of total power radiated by an antenna to the input power of an antenna. The total efficiency given as,

$$e_0 = e_r * e_c * e_d$$

Where, e_0 = Total Efficiency (dimensionless)

e_r = Reflection efficiency

e_c = Conduction efficiency

e_d = Dielectric efficiency

I. Effective Aperture

Effective Aperture is a basic antenna concept that is a measure of the power captured by an antenna from a plane wave.

J. Bandwidth (B)

The bandwidth of an antenna is defined as "the range of frequencies within which the performance of the antenna, with respect to some characteristic, conforms to a specified standard." The bandwidth can be considered to be the range of frequencies, on either side of a center frequency, where the antenna characteristics (such as input impedance, pattern, beamwidth, polarization, side lobe level, gain, beam direction, radiation efficiency) are within an acceptable value of those at the center frequency.

K. Input Impedance (Z)

Input impedance is defined as "the impedance presented by an antenna at its terminals or the ratio of the voltage to current at a pair of terminals or the ratio of the appropriate components of the electric to magnetic fields at a point."

The ratio of the voltage to current at these terminals, with no load attached, defines the impedance of the antenna as:

$$Z = R + jX$$

Where, Z = Antenna Impedance at input terminal

R = Antenna Resistance at input terminal

X = Antenna Impedance at input terminal

IV. FEEDING TECHNIQUES

Feeding techniques are used to excite the antenna patch to radiate, by direct or indirect contact. The feed of microstrip antenna can have many configurations like microstrip line, coaxial, aperture coupling and proximity coupling. But microstrip line and the coaxial feeds are relatively easier to fabricate. Coaxial probe feed is used because it is easy to use and the input impedance of the coaxial cable in general is 50Ω. There are several points on the patch which have 50Ω impedance. We have to find out those points and match them with the input impedance. These points are find out through a mathematical model. Different feeding techniques and their characteristics are described as:

TABLE II. COMPARISON OF DIFFERENT FEEDING TECHNIQUES

Characteristics	Microstrip Line Feed	Co-axial Line Feed	Aperture Coupled Feed	Proximity Coupled

				Feed
Reliability	Better	Poor	Good	Good
Impedance Matching	Easy	Easy	Easy	Easy
Spurious Feed radiation	More	More	Less	Medium
Easy of fabrication	Easy	Soldering & drilling needed	Alignment required	Alignment required
Bandwidth	2 – 5 %	2 – 5 %	2 – 5 %	13%

V. Advantages and Disadvantages

Every antenna has some advantages and disadvantages. The microstrip patch antenna also has several advantages and disadvantages over conventional microwave antenna with one similarity of frequency range from 100 MHz to 100 GHz same in both types. The various advantages and disadvantages are given in Table3.

TABLE III. ADVANTAGES AND DISADVANTAGES OF PATCH ANTENNA

Sr. no.	**Advantages**	**Disadvantages**
1	Low Profile	Low gain
2	Required no cavity backing	Low power handling capacity
3	Low weight	Low efficiency
4	Thin profile	Excitation of surface wave
5	Capable of dual and triple frequency operation	Large ohmic loss in the feed structure of arrays
6	Feed line & matching n/w can be fabricated	Complex feed structure requires high performance arrays
7	Linear & Circular polarization	Polarization purity is difficult to achieve

VI. Conclusion

This paper concludes that the Microstrip patch antenna is well suited for the WLAN and WiMAX application easily and on studying various parameters like, Gain, Return Loss, Directivity, VSWR, Antenna Efficiency, etc. We concluded that Low power handling capacity and Lower gain of microstrip antenna can be overcome by using slotted patch. Different feeding techniques and fundamental parameters of antenna have briefly explained in this paper.

References

[1] Yen-Liang Kuo and Kin-Lu Wong, "Printed Double-T Monopole Antenna for 2.4/5.2 GHz Dual-Band WLAN Operations", IEEE Transactions on Antennas and Propagation, Vol. 51, No. 9, September 2003.

[2] M A Matin, M.P Saha, H. M. Hasan, "Design of Broadband Patch Antenna for WiMAX and WLAN", IEEE Transaction, 2010.

[3] Constantine A. Balanis, Antenna theory analysis and design, 2ndedition, John Wiley &sons, Inc, 1997.

[4] Rohith K. Raj, Manoj Joseph, C. K. Aanandan, K. Vasudevan and P. Mohanan, "A New Compact Microstrip-Fed Dual-Band Coplanar Antenna for WLAN Applications", IEEE Transactions on Antennas and Propagation, Vol. 54, No. 12, December 2006.

[5] Tej Raj, Brajlata Chauhan, " Single Layer Dual band Microstrip Patch Antenna using Probe Feed", International Journal of Computer Applications (0975 – 8887) Volume 92 – No.12, April 2014.

[6] Wing Chi Mok, Sai Hoi Wong, Kwai Man Luk and Kai Frong Lee "Single-Layer Single-Patch Dual-Band and Triple-Band Patch Antennas" IEEE transactions on antennas and propagation, vol. 61, no. 8, August 2013.

[7] Kin-Fai Tong, Kwai-Man Luk, Senior Member, IEEE, Kai-Fong Lee, Fellow, IEEE, and Richard Q. Lee "A Broad-Band U-Slot Rectangular Patch Antenna on a Microwave Substrate" IEEE transactions on antennas and propagation, vol. 48, no. 6, June 2000.