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Multiband Microstrip Antenna for Wi-MAX Application-A study

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Abstract---
The wireless revolution is transforming the existing global telecommunications networks into an integrated system providing a broad class of communication services to customers anywhere, anytime in motion or fixed. An antenna is an important device in wireless communication system as its performance will have direct effect on the total system. The continuous shrinking of size of the electronic systems demands small size of antenna elements which can cater the need of multiband operation in order to fit properly in wireless devices without compromising the radiation properties of the antenna. This paper presents a review of the research work done by various authors on the topic multiband microstrip antenna for Wi-MAX application in the recent past.

Keywords---Wi-MAX, multiband microstrip antenna

1. INTRODUCTION

Now a days wireless communication is the fastest growing area of the communication field. There are many applications such as mobile radio, Satellite etc. In Wireless communication weight, size, cost, performance and ease of installation are major drawback. The main aim of the wireless communication is supporting information exchange between people and devices. That will allow multimedia communication from anywhere, anytime in the world. In last few years, the development of Wi-MAX (Worldwide Interoperability for Microwave Access) and other wireless application like WLAN, GSM etc. represented one of the principal interests in the communication field. Also, today's technology demands antennas which can operate on different wireless communication bands and it should have different features like low cost, low weight, low profile and are capable of performing multi frequency operation.

2. MICROWAVE REGION

Microwave spectral region is a form of electromagnetic radiation with wavelength ranging from as long as one meter to as short as one millimeter, or in terms of frequencies between 0.3 GHz and 300 GHz. This broad definition includes both UHF and EHF bands. In all cases, microwave includes the whole SHF band (3 to 30 GHz, or 10 to 1 cm) at minimum, with RF engineering often restricting the range between 1 and 100 GHz (300 and 3 mm). Most common applications are within the 1 to 40 GHz range. [1, 2]

The various band of microwave region is given in Table 1 below.

Sr. No.	Name of band in microwave	Frequency Range	Application
1	High Frequency(HF)	3 - 30 MHz	Shortwave broadcast, RFID, Marine & mobile Communications
2	Very High Frequency (VHF)	30 - 300 MHz	FM, Television broadcasts and Line of sight communications, Mobile communications, Weather radio
3	Ultra High Frequency (UHF)	300 - 3000 MHz	Television broadcasts, Microwave oven, Microwave-device/communication, Wireless LAN, Bluetooth, ZigBee, GPS
4	Long wave (L)	1 - 2 GHz	Military telemetry, GPS, Mobile phone (GSM),Amateur radio
5	Short wave(S)	2 - 4 GHz	Weather radar, Surface ship radar, Some satellite communication
6	C-Band	4 - 8 GHz	Long distance communication
7	X-Band	8 - 12 GHz	Satellite communication, Terrestrial broadcast radar, Space communication, Amateur radio
8	Ku-Band	12 - 18 GHz	Satellite communication
9	K-Band	18 - 27 GHz	Astronomical observation, Automotive radar, Satellite communication, Radar
10	Ka-Band	27 - 40 GHz	Satellite communication

11	V-Band	40 - 75 GHz	Millimeter wave radar research and other kinds of Scientific research
12	W-Band	75-110 GHz	Millimeter wave radar research, Military radar targeting and tracking applications, Satellite communication, Non-military communication
13	Millimeter-Band	110 - 300 GHz	Millimeter scanner, DBS, Direct-energy weapon, Satellite television broadcasting, Amateur radio

Table 1: Various band of microwave region

2.1 Importance

- Antenna gain is proportional to the electrical size of the antenna. At higher frequencies, more antenna gain can be obtained for a given physical antenna size, and this has important consequences when implementing microwave systems.[3]
- More bandwidth (directly related to data rate) can be realized at higher frequencies.[2,3]
- Line of sight communication is of prime focusing case of microwave frequency signals as they are not bent by the ionosphere as are lower frequency signals. Satellite and terrestrial communication links with very high capacities are therefore possible, with frequency reuse at minimally distant locations.[2]
- Various molecular, atomic and nuclear resonances occur at microwave frequencies, creating a variety of unique applications in the areas of basic science, remote sensing, medical diagnostics & treatment and heating methods.[4]

2.2 Microwave Devices

2.2.1 Waveguides:
Any linear hollow metallic structure which confines microwave energy signals by channeling them satisfactorily from one point to another with the aid of multiple reflections between the opposite walls of the structure can be defined as a waveguide.[2,4] Various prevailing waveguides are rectangular waveguides and circular waveguides.

2.2.1.1 Rectangular waveguide
Rectangular waveguides are one of the earliest types of transmission lines used to transport microwave signals and used for many applications. Rectangular waveguides can propagate TM and TE modes but not TEM waves since only one conductor is present.[1,2] The TM and TE modes of a rectangular waveguide have cutoff frequencies below which propagation is not possible.

2.2.1.2 Circular waveguide
A hollow, round metal pipe supports TE and TM waveguide modes. Dominant mode for circular waveguide is TE_{11} mode. In this waveguide TE_{10} mode cannot be propagated but TE_{01} mode can be propagated.[4]

2.2.1.3 Ridge waveguide
The ridge waveguide consists of a rectangular waveguide loaded with conducting ridges on the top and/or bottom walls. This loading tends to lower the cut-off frequency of the dominant mode, leading to increased bandwidth and better impedance characteristics. Ridge waveguides are often used for impedance matching purposes, where the ridge may be tapered along the length of the guide, but the power handling capacity gets decreased.[1]

2.2.1.4 Coplanar waveguide
The coplanar waveguide can be viewed as a slot line with a third conductor centered in the slot region. Due to the presence of the additional conductor, it can support even or odd quasi-TEM modes, depending on the direction of the electric fields in the two slots.[1]

2.2.2 Couplers:
A directional coupler is a passive device which couples part of the transmission power by a known amount out through another port by setting two transmission lines close enough together such that energy passing through one is coupled to the other. There are some different types of waveguide directional couplers.[2]

2.2.2.1 Bethe Hole Coupler
The directional property of all directional couplers is produced through the use of two separate waves or wave components, which add in phase at the coupled port and are canceled at the isolated port. One of the simplest ways of doing this is to couple one waveguide to another through a single small hole in the common broad wall between the two waveguides. Such a coupler is known as a Bethe hole coupler.[2,4]

2.2.2.2 Multi-hole coupler
If the coupler is designed with a series of coupling holes and the extra degrees of freedom can be used to increase this bandwidth such a couplers is called multi-hole coupler.[1]

2.2.2.3 The Quadrature Hybrid Coupler

The quadrature hybrid coupler is 3 dB directional coupler with a 90^0 phase difference in the outputs of the through and coupled arms.[4]

2.2.2.4 Coupled Line Directional Coupler

When two unshielded transmission lines are in close proximity, power can be coupled from one line to the other due to the interaction of the electromagnetic fields. Such lines are referred to as coupled transmission lines with coupled line directional coupler.[1]

2.2.3 Antennas

An antenna is an electrical device which converts electric power into radio waves, and vice versa. Antennas are essential components of all equipment that uses radio. They are used in systems such as radio broadcasting, broadcast television, two-way radio, communications receivers, radar, cell phones, and satellite communications, as well as other devices such as garage door openers, wireless microphones, Bluetooth-enabled devices, wireless computer networks, baby monitors, and RFID tags on merchandise.[3] Comparison of some different types of antennas is given as in Table 2 below.

Antenna Type/ Parameter	Monopole	Slot	Microstrip Patch	PIFA
Radiation Pattern	Omni-directional	Roughly omni-directional	Directional	Omni-directional
Gain	High	Moderate	High	Moderate to high
Modeling & Fabrication	Modeling is difficult	Fabrication on PCB can be done	Easier to fabricate and model	Easier fabrication using PCB
Application	Radio broadcast, Vehicular antenna	Radar, Cell phone base station	Satellite communi-cation, Aircrafts	Internal antennas of mobile phones
Merits	Compact size, Low fabrication cost, Large bandwidth support	Radiation characteristics remains unchanged due to tuning, Design simplicity	Low cost, Low weight, Easy in integration	Small size, Low cost, Reduced backward radiation for minimizing SAR
Problems	Difficult fabrication at higher frequencies (>3 GHz)	Size constraint for mobile handheld devices	No bandpass filtering effect, Surface-area requirement	Narrow bandwidth characteristics

Table 2: Comparison of various antennas

3. RELATED WORK

The recent development of different techniques in design of antennas enabled a breakthrough in many different areas of science and technology. Microstrip patch antenna has gained attraction for wide application in microwave frequencies.

Very recently R.Samson Daniel, has developed and simulates an M-shape microstrip antenna for various wireless applications[5] as shown in figure 2 below.

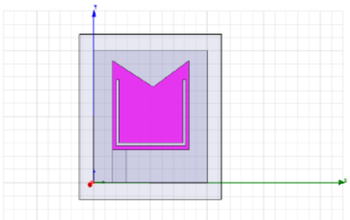

Figure 1: M-shape microstrip antenna [5]

The radiating patch is cut with U-shaped slot to generate multiple frequencies for various wireless applications.[5] This design includes five bands for Bluetooth, Wi-MAX, WIFI and C-band applications.

Gehan Sami, Mahmoud Mohanna, Mohamed L.Rabeh, have developed A tri-band patch antenna[6] that is used for wireless communication systems as shown in figure 3 below.

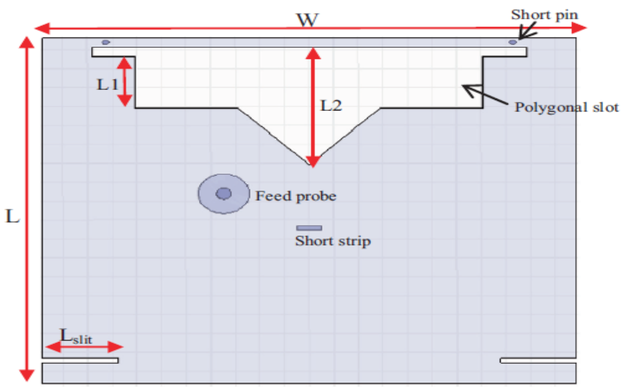

Figure 3: Configuration view of tri-band antenna[6]

Here authors have proposed tri-band patch antenna. The tri-band operation was obtained by proper loading for a rectangular patch antenna using slots and shorting pins. The optimal location and dimension for the loaded elements were obtained with the aid of interfacing a Genetic Algorithm (GA) model. The results obtained from simulation show 5.8% impedance matching band width at 2.4 GHz, 3.7% at 3.5 GHz and 1.57% at 5.7 GHz. [6]

Swaraj Panusa and Mithlesh Kumar, have developed a quad-band U-slot microstrip patch antenna[7] for wireless application like Wi-MAX, GPS, Bluetooth, Wi-Fi, WLAN etc. as shown in figure 4 below.

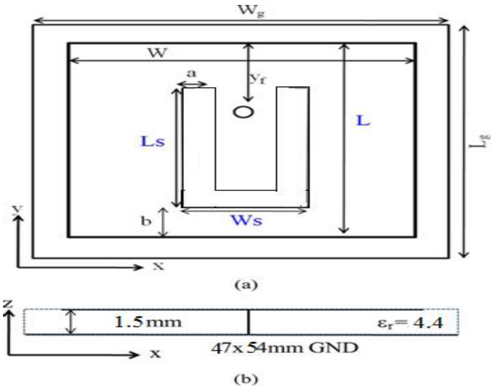

Figure 2: The geometry of quad-band U-slot microstrip patch antenna [7]

This antenna is designed using coaxial feeding technique and is used to feed the antenna with 50 ohm impedance. Also this antenna has good radiation characteristics and gains, in the four operating bands 1.43-1.5 GHz, 2.4–2.55 GHz, 3.8–3.98 GHz, and 5.2–5.4 GHz.[7]

Syed Imran Hussain Shah and Shahid Bashir, have developed a multiband microstrip patch antenna for portable communication system[8] as shown in figure 3.

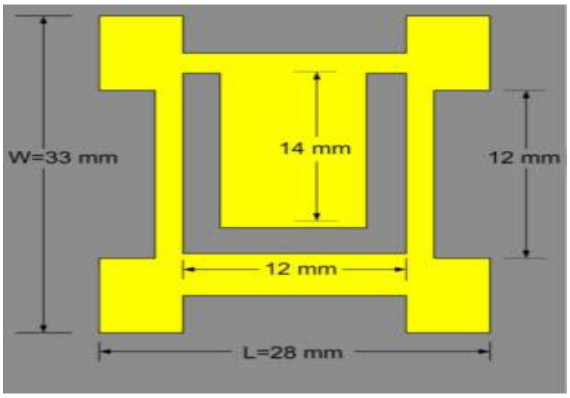

Figure 4: Front view of patch antenna

Using combination of U-Shaped and L-Shaped slots on the ground plane and U-Shaped slot on the fractal patch of antenna with shorting pin between patch and ground they have obtain an antenna with size reduction of 89%as compared to the conventional antenna. This antenna has high gain and sufficient impedance bandwidth for each band.[8] It is used for many applications like in Mobile phone for Wi-MAX, GSM 1800/ 3G/PCS, Bluetooth, GPS and for WLAN etc.

Ruchi Kadwane, Vinaya Gohokar, have developed a low-profile compact microstrip patch antenna for multiband application[9] as shown in figure 5.

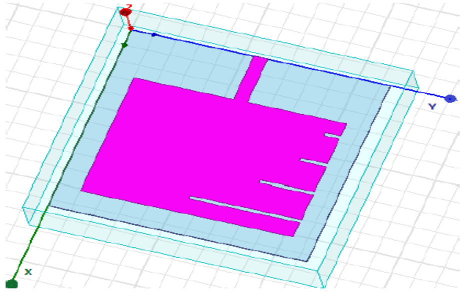

Figure 5: low-profile compact microstrip patch antenna [9]

This antenna consists of a patch with four narrow slits and ground plane to generate six bands of frequency at 1.34, 1.99, 2.98, 3.27, 3.56 and 3.86GHz for different wireless Application. This antenna has a good return loss and radiation patterns are Omni-directional for all frequency band. so, this antenna is highly suitable for L and S band applications.[9] Here the multiband operation is achieved by cutting four narrow slits on the patch.

S.Sreenath Kashyap and his team designed a simple microstrip patch antenna using different substrate material which enables antenna for ISM Band application.[10]

Very recently Dr. Vedvyas Dwivedi, Y.P.Costa & team designed an antenna using metamaterial. An S shape structured metamaterial antenna for 2.4GHz is designed which enhances potential application in wireless communication.[11]

4. CONCLUSION

Antenna has gained prime importance in the field of communication, security, material testing, and sensing application. New types of electronic and photonic structures are needed for efficient communication.

In table1 represents the various bands of EM spectrum along with its application. This paper presents a summary of recent development of various structures of antennas for microwave applications have been listed for reference. The design aspect such as dimension will play crucial role in determining resonant frequency. Despite of obstacles the potential for new valuable application is driving towards research in communication through Wi-MAX at 3.6GHz.

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