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Integrated Aperture Shaped Microstrip (ASM) Antenna With Added CDMB/WiBro/WLAN/CMMB Bands

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Abstract—.
The microstrip antenna is the most popular configuration and is very easy to analyze. This paper presents a small-sized, low-profile Integrated Aperture shaped multi-application microstrip antenna. The antenna exhibits a single -band operation covering 2GHz to 4GHz frequency band useful for China Digital Multimedia Broadcast (CDMB) /Wireless Broadband(WiBro)/Wireless Local Area Network(WLAN)/ China Mobile Multimedia Broadcasting (CMMB) Bands . It is fed by a microstrip line and built on a FR-4 substrate with 30 X 30 mm^2 surface area. The impedance, Voltage Standing Wave Ratio(VSWR), radiation response , etc. properties of the antenna are studied both theoretically and experimentally. The antenna shows omnidirectional radiation patterns. The calculated and measured results agree well.

Index Terms— **Microstrip antenna, return loss, VSWR, radiation efficiency.**

I. Introduction

The demand of the microstrip antenna based applications has been increasing rapidly with the invention of the microstrip antenna. Because of characteristics such as -small size, lightweight, low profile, and low manufacturing cost, easy fabrication process, etc. microstrip antenna is always retained as one of the most dynamic issue in communication field[1]. Furthermore, the current satellite communication applications, mobile television, wireless broadband and wireless local area network benefits greatly from the small-size and low-profile of the microstrip antenna. They are extremely compatible for embedded antennas in handheld wireless devices such as cellular phones, pagers etc. The telemetry and Square rectangular, dipole Circular, Triangular Circular ,Ring Elliptical communication antennas on missiles need to be thin and conformal and are often microstrip patch antennas. Another area where they have been used successfully is in Satellite communication. One reason of increasing it's popularity is their ability to printed directly on circuit board.

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Some of their principal advantages are light weight low volume, low profile planar configuration which can be easily made conformal to host surface, low fabrication cost hence can be manufactured in large quantities, it supports both,linear as well as circular polarization, can be easily integrated with microwave integrated circuits (MICs),capable of dual and triple frequency operations,mechanically robust when mounted on rigid surfaces.

Microstrip patch antennas suffer from a number of disadvantages as compared to conventional antennas. Some of their major disadvantages discussed are narrow bandwidth, low efficiency, low Gain, extraneous radiation from feeds and junctions, poor end fire radiator except tapered slot antennas, low power handling capacity, surface wave excitation[2].

In this paper we have designed a small-size CPW-fed multi-application microstrip antenna with the frequency band 2GHz to 4 GHz which includes CDMB, WiBro, WLAN and CMMB.

The first technology considered for mobile handheld devices is 3G technology. International Mobile Telecommunications -2000 (IMT-2000), better known as 3G or 3rd Generation, is a generation of standards for mobile phones and mobile telecommunications services fulfilling specifications by the International Telecommunication Union. One of these mobile broadcasting systems is China Multimedia Mobile Broadcasting (CMMB), which is a mobile television and multimedia standard developed and specified in China During the Boao Forum for Asia11 in 2003, China began to launch mobile TV services, which was mainly used in the broadcasting mode. In 2005, the two main telecom companies had launched their cellular mobile TV services In October 2006, the State Administration of Radio, Film and Television (SARFT) 12officially promulgated its own standard – CMMB (China Multimedia Mobile Broadcasting), and subsequently broadcast its free CMMB mobile TV pilot in some major cities across the country. As of the 2009 Chinese New Year, the CMMB mobile TV signal had extended to 150 cities and had more than 3 million users. China Mobile Multimedia Broadcasting (CMMB) is based on the Satellite and Terrestrial Interactive Multiservice Infrastructure (STiMi), developed by TiMiTechDVB-SHstandard for digital video broadcast from both satellites and terrestrial repeaters to handheld devices[3].

The next technology is a wireless broadband Internet (WiBro) technology developed by the South

Korean telecoms industry. WiBro is the South Korean service name for IEEE 802.16e (mobile WiMAX) international standard. WiBro was devised to overcome the data rate limitation of mobile phones (for example CDMA 1x) and to add mobility to broadband Internet access. By the end of 2012, the Korean Communications Commission intends to increase WiBro broadband connection speeds to 10Mbit/s, around ten times the current speed, which will complement their 1Gbit/sec fibre-optic network[4].

On May 18,2007 China Association for Standardization (CAS) approved and released in Tianjin the China Digital Multimedia Broadcast (CDMB) standard numbered CSA158-2007. According to resources, by adopting the CDMB standard on which China owns intellectual property, CDMB's core technology is the DAB-based channel transmission technology and AVS-based signal processing technology. DAB technology is the technical specification on Digital Audio Terrestrial Broadcasting (GY/T214-2006) recommended by the State Administration of Radio, Film and Television; and AVS is the national standard (GB/T20090) issued by National Standards Administration [5].

II. Design Parameters

In order to simplify analysis and performance prediction, the patch is generally square, rectangular, circular, triangular, elliptical or some other common shape. For a rectangular patch, the length L of the patch is usually $0.3333\lambda_0 < L <$ $0.5\lambda_0$ where λ_0 is the free-space wavelength. The patch is selected to be very thin such that $t << \lambda_0$ (where t is the patch thickness). The height h of the dielectric substrate is usually $0.003\ \lambda_0 \le h \le 0.05\lambda_0$.

For good antenna performance, a thick dielectric substrate having a low dielectric constant is desirable since this provides better efficiency, larger bandwidth and better radiation. However, such a configuration leads to a larger antenna size. In order to design a compact Microstrip patch antenna, higher dielectric constants must be used which are less efficient and result in narrower bandwidth. Thus the dielectric constant of the substrate (ε_r) is typically in the range $2.2 \le \varepsilon_r \le 12$.

In designing of patch, the rectangular shape has been chosen and the effect of the aperture on the return loss is investigated. The antenna design starts with a conventional rectangular shape patch and cutting slot is added for optimization. Fig. 1(a) and fig. 1(b) shows the front view and side view of ASM antenna.There are a variety of types of substrate materials. the relative dielectric constant of these materials can be 1 to **10.** The most popular type of material is teflon-based, with a relative dielectric constant between 2 and 3. This teflon-based material, also called PTFE (polytetrafluoroethylene) , has a structural form very similar to, but has much lower insertion loss than, the fiberglass material that often is used for digital circuit boards. The selection of the correct material for the microstrip antenna, depending upon the applications, should be based on cost, insertion loss, thermal stability, dielectric constant etc..

The developed antenna is fabricated on a low-cost FR4 substrate with dielectric constant $\varepsilon_r = 4.4$, loss tangent tan δ = 0.02, substrate height h = 0.76mm. The proposed ASM antenna with dimensions is shown in fig.2.The patch is of length *H2*, width *W2*, and sitting on top of a substrate (some dielectric circuit board) of thickness h with permittivity(ε_r). The ground plane dimensions are $W1$ = 30mm ,H = 30 mm, and the rectangular aperture dimensions are $W2$ = 14mm, $H2$ = 8 mm. The other dimensions we have taken into account are H1=15mm, H3=H4=6mm, H5=2.5mm..

The commercial simulation software Ansoft HFSS 12.0 based on the finite element method (FEM) is employed to perform the design and optimization process.

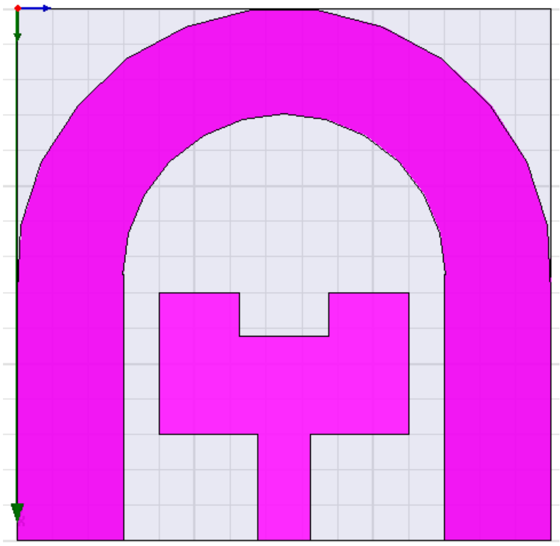

Fig.1(a) ASM Antenna Design (Front View)

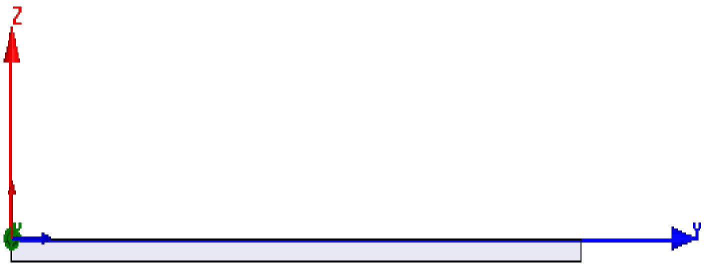

Fig.1(b) ASM Antenna Design (Side View)

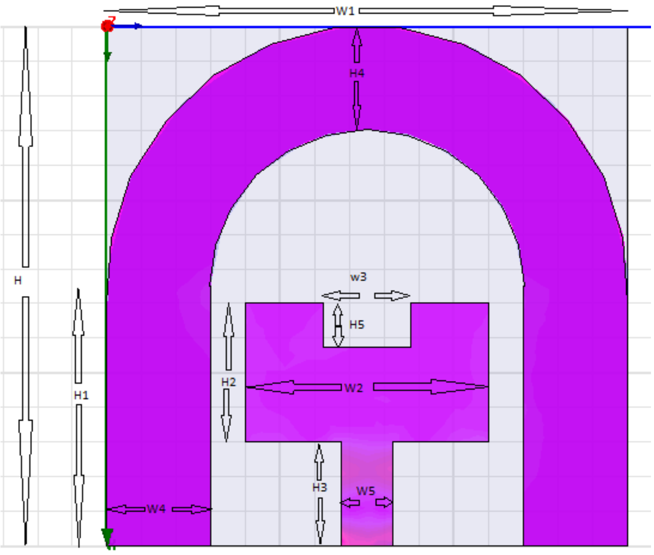

Fig.2 Dimensions of ASM Antenna

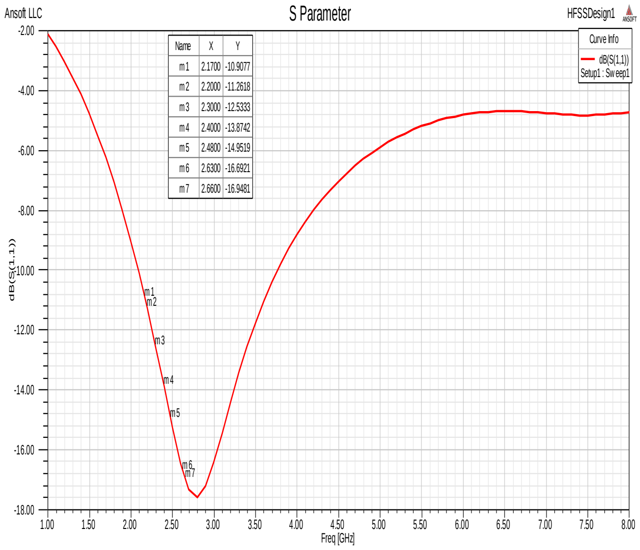

Fig.3 S-parameter plot of ASM Antenna

III. Result and Discussion

A. Return loss

Return loss is measure of impedance match quality and depend on the value of reflection coefficient Γ, or S_{11}.

Antenna return loss is calculated by the following equation:

$$\text{Return Loss} = -10\log|S11|^2, \text{ or } -20\log(|\Gamma|) \quad (1)$$

VSWR and return loss are both dependent on the measurement of the reflection coefficient Γ. Γ is defined as ratio of the reflected wave *Vo-* to the incident wave *Vo+* at a transmission line load as

$$\Gamma = Vo-/Vo+$$

$$= Z_{line} - Z_{load} / Z_{line} + Z_{load} \quad (2)$$

Z_{line} and Z_{load} are the transmission line impedance and the load (antenna) impedance, respectively.A good impedance match is indicated by a return loss less than -10 dB. A summary of desired antenna impedance parameters include Γ<0.3162, VSWR<2, and Return Loss < -10 dB.

The S-parameter plot and VSWR plot of ASM antenna is shown in fig.3and fig.4.The simulated return loss S_{11}has a frequency range below -10 dB from 2-4 GHz, which covers the entire CDMB, WiBro, WLAN and CMMB band.

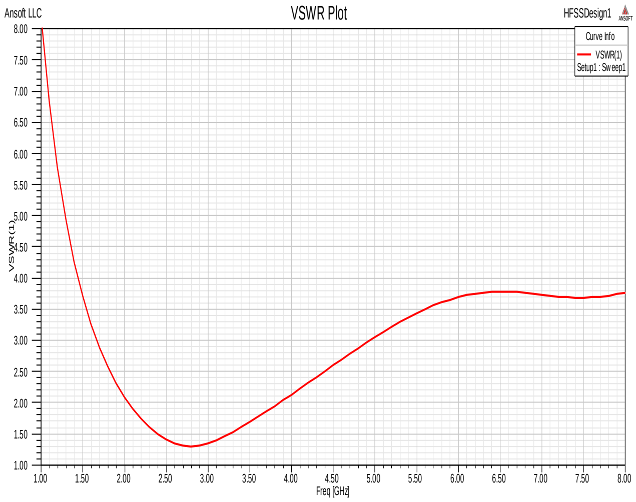

Fig.4 VSWR plot of ASM Antenna

B. Radiation patterns

The radiation pattern (or antenna pattern) is the representation of the radiation properties of the antenna as a function of space coordinates. In most cases, it is determined in the far-field region where the spatial (angular) distribution of the radiated power does not depend on the distance. Usually, the pattern describes the normalized field (power) The radiation property of most concern is the two- or three-dimensional (2D or 3D) spatial distribution of radiated energy as a function of the observer's position along a path or surface of constant radius. The 3-D radiation pattern of ASM antenna is shown in below fig.5.

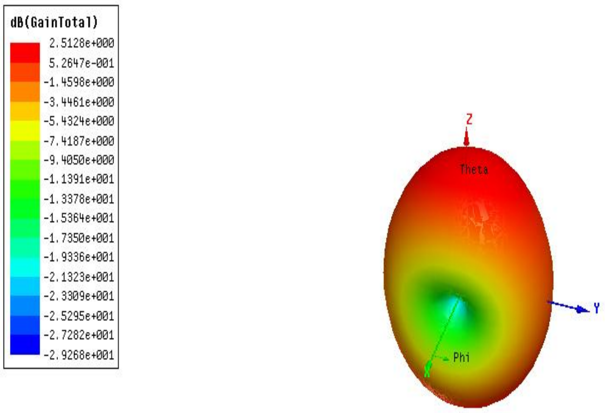

Fig.5 3-D radiation pattern of ASM Antenna

For a linearly polarised antenna, its performance is often described in terms of its principle *E*-plane and *H*-plane patterns. The *E*-plane is defined as the plane containing the electric field vector and the direction of maximum radiation whilst the *H*-plane is defined as the plane containing the magnetic-field vector and the direction of maximum radiation Simulated radiation far-field patterns for the proposed antenna in E-plane and H-plane is shown in fig. 6 and fig.7.

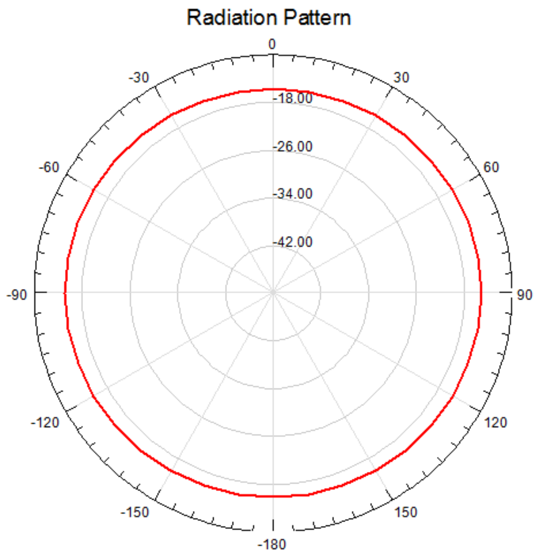

Fig.6 Simulated radiation far-field patterns for the proposed antenna in E-plane

There are three common radiation patterns that are used to describe an antenna's radiation property:

(a) *Isotropic* - A hypothetical lossless antenna having equal radiation in all directions. It is only applicable for an ideal antenna and is often taken as a reference for expressing the directive properties of actual antennas.

(b) *Directional* - An antenna having the property of radiating or receiving electromagnetic waves more effectively in some directions than in others. This is usually applicable to an antenna where its maximum directivity is significantly greater than that of a half- wave dipole.

(c) *Omni-directional* - An antenna having an essentially non-directional pattern in a given plane and a directional pattern in any orthogonal plane.

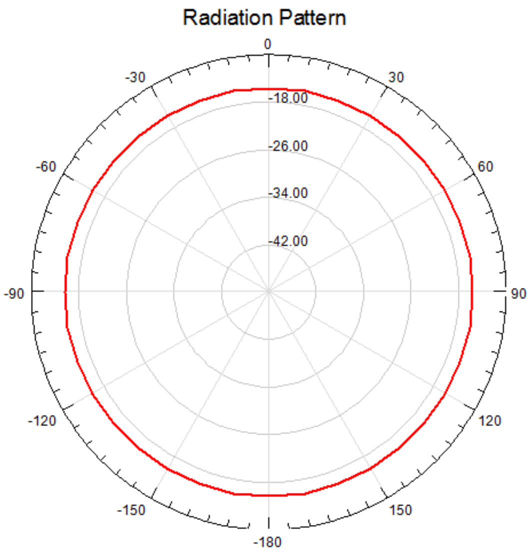

Fig.7 Simulated radiation far-field patterns for the proposed antenna in H-plane

The antenna results of designed aperture shaped Microstrip Antenna is calculated using Ansoft HFSS12.0 and tabulated as below.

Table1: Results of designed ASM antenna

Sr. No.	Quantity	Value	Units
1	Radiated power	0.93235	W
2	Incident power	0.99999	W
3	Accepted power	0.95888	W
4	Radiation efficiency	97.233%	
5	Front to back ratio	1.2422	

IV. Conclusion

The paper presents a simple design of **ASM** antenna for wireless communication application. By using HFSS software we calculated VSWR, Return loss and radiation pattern. . From the results, it can be concluded that the radiation patterns from 2 GHz to 4 GHz are stable and the radiation patterns are omni-directional in the azimuth (horizontal) plane. From the result we find that rectangular microstrip antenna well operate in 2GHz to 4 GHz band.

V. Future work

Future research directions in this area may involve antenna miniaturization as well as the optimization of the current distribution on the antenna so as to reduce signal distortion. In order to avoid interference with other existing communication systems, band notching will be required, which may be achieved in the proposed ASM antenna by cutting slots on the radiators.

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