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Compact HMSIW Mobile Antenna for WLAN Application

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ABSTRACT

Antennas for mobile phone handsets are generally required to have compactness, complete built-in mountability, multiband operation and environmental isolation, as well as broad bandwidth and high efficiency. The substrate integrated waveguide (SIW) is a low cost realization of the traditional waveguide. A compact dual-frequency half mode substrate integrated waveguide (HMSIW) antenna with microstrip fed for wireless applications is proposed. The proposed antenna generates two bands at 2.45 and 5.8 GHz for wireless local area network (WLAN) access points and point to point application respectively. The proposed antenna is capable of achieving a size reduction of nearly 50% in comparison to conventional SIWs. The design involves open loop resonator embedded with dumbbell shape resonator to obtain dual resonant frequency. The HMSIW technology is introduced by adding vias on the side wall of the open loop resonator. It is used to achieve particular band with good return loss performance. The model of the antenna is built and simulated using ADS software. The designed antenna having the return loss of 12.353 dB for 2.45 GHz and 13.869 dB for 5.8 GHz and the size of 11 mm x 17 mm, which is very compact compared to other design. The simulated results prove the compatibility of the HMSIW antenna with the 2.45 and 5.8 GHz WLAN application.

INTRODUCTION

The progress of wireless communications equipment including mobile phones is ever accelerating toward implementation of the ubiquitous society, placing more importance to the antenna technologies day by day. As handsets improve in compactness and functions in recent years, the antennas for these equipment have come under the spotlight, transforming their longstanding impression of “an accessory for wireless communications equipment” into “a key device for wireless communication.” Naturally, mobile phone handsets are strongly required to be small in size. But also the suitability for the environment of use specific to mobile phones. Recently, the applications of wireless local area network (WLAN) have received much attention. Mobile communication terminal, such as antenna for WLAN is required to be as small as possible in dual frequency band. Microstrip is the best candidate as it can provide favourable features, such as low weight, flat profile, and low cost of production as well as useful radiation characteristic.

Wireless Local Area Network (WLAN) is one of the best network used in the communication system. According to the Federal Communications Commission (FCC), WLAN frequency is allocated under unlicensed spectrum category, where it falls under the ISM band. Since WLAN frequency is under unlicensed spectrum category, its frequency has been used in many applications and devices, such as Bluetooth, microwave oven, and cordless phone. This networks usually uses 2.45 GHz frequency for the Access Points and 5.8 GHz frequency for point to point applications since 1985.

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After then considerable research has been done whereas in 2011 a simple, compact EBG microstrip antenna is proposed that covers a wideband of 250 GHz and the design is conformal with the 2.45 GHz ISM band (WLAN, IEEE 802.11b and g)/Bluetooth/RFID applications (Alam, M.S., *et al*., 2011). Then in the year of 2012 a new design of dual-band circular polarized (CP) microstrip antenna for ISM band applications (2.45 GHz and 5.8 GHz) was introduced. The proposed dualband CP microstrip antenna with compact design has achieved design intention of having return loss of < −10 dB and axial ratio of < 3 dB for both frequencies of 2.45 GHz and 5.8 GHz (Norhanani ZAKARIA, *et al*., 2012). Then in the year of 2013 a compact dual-band transparent antenna with co-planar waveguide (CPW)-fed for wireless applications in the unlicensed industrial, scientific and medical (ISM) band was proposed. The proposed antenna generates two bands at 2.4 and 5.8 GHz for Wireless Local Area Network (WLAN) access points and point-to-point applications, respectively (Rani, M.S.A., *et al*., 2013). The design of Swastika shaped microstrip patch antenna for Industrial Scientific and Medical (ISM) band applications was proposed in 2015. The design has four slots as same as Swastika shape into it and it resonates at 2.416 GHz frequency (Udit Raithatha, S. *et al*., 2015). In the same year, the microstrip patch antenna is designed for Industrial Scientific and Medical (ISM) band applications, which resonates at 2.404 GHz. The size of the structure is comparatively smaller and microstrip line feed is used as the feeding method (Udit Raithatha1, S. Sreenath Kashyap, 2015).

The substrate integrated waveguide (SIW) is a low cost realization of the traditional waveguide synthesized in a dielectric substrate, where the side walls are substituted by two parallel rows of via holes placed so that there is no power leakage. The structure of the half-mode substrate integrated waveguide (HMSIW) is similar to that of the SIW, but with the waveguide width half of conventional SIWs. Consequently, the HMSIW is capable of achieving a size reduction of nearly 50% in comparison to conventional SIWs, while keeping the main properties of the SIW.

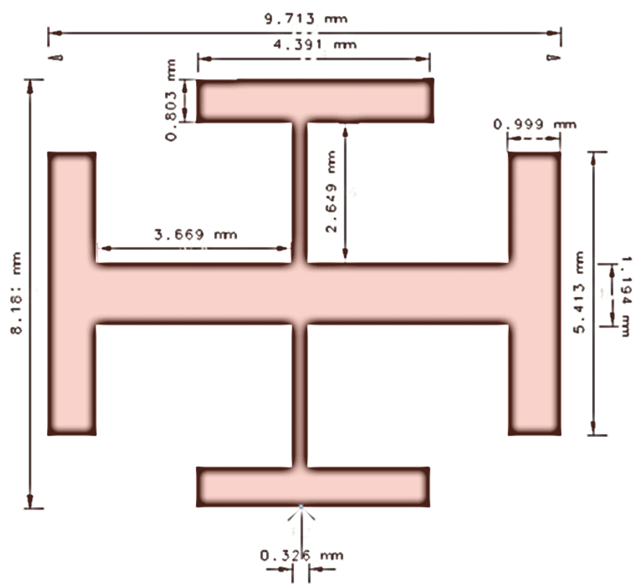
In this paper a dual-frequency half mode substrate integrated waveguide (HMSIW) antenna is designed for WLAN application operating at 2.45 GHz and 5.8 GHz frequencies which is capable of achieving a size reduction of nearly 50% in comparison to conventional SIWs.

Design Of Hmsiw Antenna:

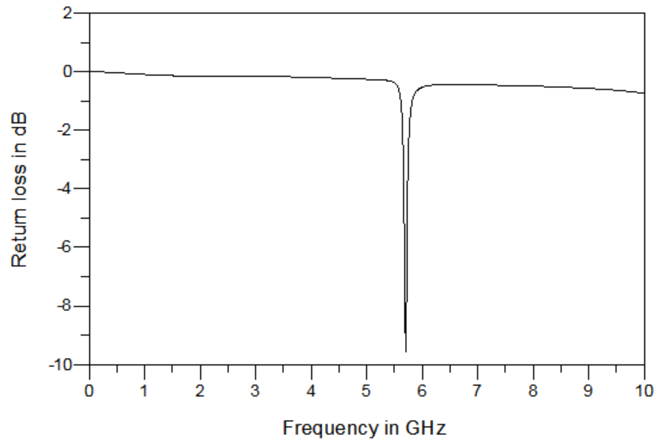
A. Design of Dumbbell Shape Resonator:

The design of the compact HMSIW mobile antenna consists of open loop resonator embedded with dumbbell shape resonator. The dumbbell shape resonator which is a basic resonator is initially designed. Due to its resonant behaviour it may be compared to the series resonator (CLC circuit). The equivalent circuit of the dumbbell shape resonator consists of a capacitor (C), an inductor (L) and a capacitor (C) in series. The length and width of the resonator plays a very important role to find the resonant behavior of the dumbbell shape resonator.

The layout of the dumbbell shape resonator and its equivalent circuit is shown below



(a)



(b)

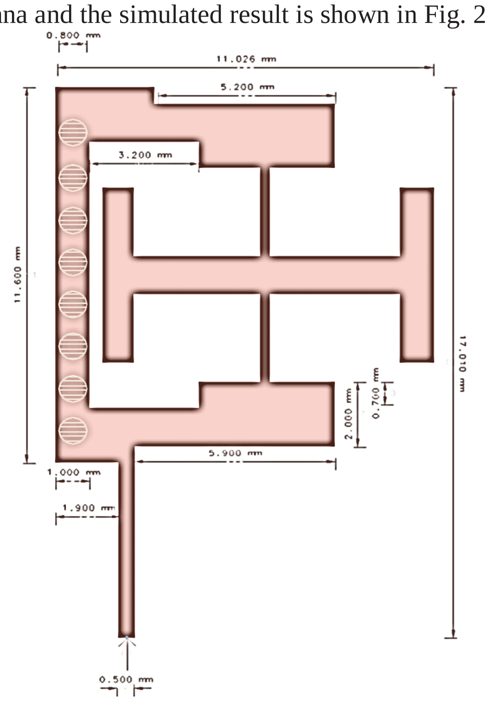
Fig. 1: Layout of dumbbell shape resonator (a) and its simulated S11 result (b).

B. Design of HMSIW antenna:

Then the dumb-bell shape resonator is embedded with open loop resonator integrated with one side vias attached to a microstrip feeding line which is nothing but HMSIW. A half mode substrate integrated waveguide (HMSIW) antenna is chosen because it provides dual frequencies. The proposed HMSIW antenna is fed by a microstrip feed. In this type of feed technique, a conducting strip is connected directly to the edge of the microstrip patch. The conducting strip is smaller in width as compared to the patch. This kind of feed arrangement has the advantage that the feed can be etched on the same substrate to provide a planer structure. The microstrip offers several advantages including Simple design, allows for planar feeding, easy to obtain input match with some disadvantages of Significant line radiation for thicker substrates, for deep notches, pattern may show distortion.

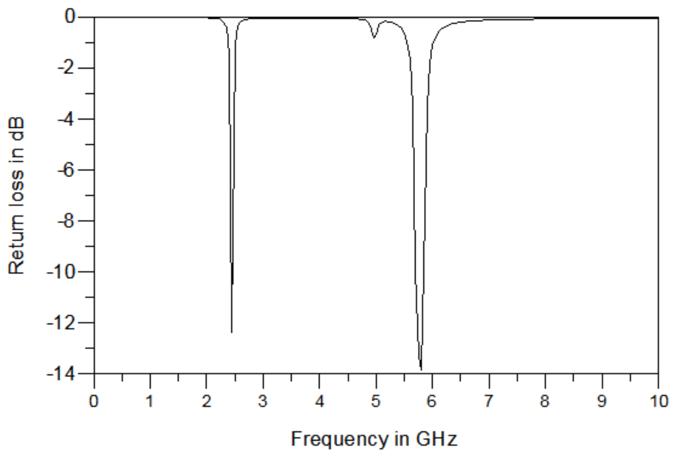
This design involves the design of antenna with dumb-bell stub embedded open loop resonator integrated with one side vias. The feeding technique followed is microstrip feeding. The half mode (a row of vias) SIW antenna for 2.4 GHz is initially designed. Then its made to resonate to dual frequency by varying dimensions of the feeding structure. The dual mode is obtained in addition to 2.45 GHz, which is changed to single mode as from 5.7 and 5.8 GHz (dual mode) to 5.8 GHz (single mode) by varying dimensions of open loop structure. Then the return loss is improved by varying dimensions of dumbbell structure and feeding structure. Then the curve is smoothened by varying the feeding structure to optimize the output.

The layout of the HMSIW antenna and the simulated result is shown in Fig. 2. below



(a)

Australian Journal of Basic and Applied Sciences, 10(1) January 2016, Pages: 439-442



(b)

Fig. 2: Layout of HMSIW antenna (a) and its simulated S11 result (b).

A comparison of various papers on the WLAN applicable mobile antenna is shown below in a tabulation. Where the overall dimension of the antennas is large when compared to the proposed HMSIW antenna. Therefore, the proposed HMSIW antenna is very compact when compared to other antenna designs. A size reduction of greater than 50% is achieved by using the HMSIW technology.

Title	Frequency with return loss	Size
Proposed Compact HMSIW Mobile Antenna for WLAN Application	Return loss of -12.353 dB for 2.45 GHz and -13.869 dB for 5.8 GHz	11 x 17 mm
Design Analysis of An Electromagnetic Band Gap Microstrip Antenna, 2011	2.45 GHz with return loss >-10dB	34.5 x 34.5 mm
Design of Stacked Microstrip Dual-band Circular Polarized Antenna, 2012	2.45 GHz and 5.8 GHz with return loss >-10dB	60 x 60 mm
Dual-band Transparent Antenna for ISM Band Applications, 2013	2.45 GHz and 5.8 GHz with return loss >-10dB	60 x 60 x 2.075 mm
Swastika Shaped Microstrip Patch Antenna for ISM Band Applications, 2015	2.45 GHz with return loss >-10dB	29.95 x 38.13 mm
Microstrip Patch Antenna for ISM Band Applications, 2015	2.45 GHz with return loss >-10dB	30.14 x 39.92 mm

Fig. 3: Comparison of overall dimension of the proposed antenna and other antenna types for WLAN application.

Conclusion:

In this paper, the performance of a compact HMSIW mobile antenna for WLAN application has been presented. The antenna operates well at return loss of -12.353 dB for 2.45 GHz and -13.869 dB for 5.8 GHz and the size of 11 mm x 17 mm which is very compact compared to other design.

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