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DESIGN OF CPW-FED MONOPOLE ANTENNA WITH L- SHAPE AND T-SHAPE FOR WLAN/WI-MAX APPLICATIONS

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Abstract
A novel dual-band design of a finite ground coplanar waveguide (CPW)-fed monopole antenna is presented for simultaneously satisfying wireless local area network (WLAN) and worldwide interoperability for Microwave Access (WiMAX) applications. The proposed antenna, comprising a rectangular planar patch element embedded with L shape and T-shape slots in the middle of the patch element. The simulated -10 dB bandwidth for return loss is from 2.0 to 2.2 GHz and 2.8GHz to 3.1 GHz, covering some of the WiMAX and WLAN bands. Prototypes of the obtained optimized antenna have been designed and constructed. The Antenna has 22.5 % (-10 dB return loss) band width ranging from 2 to 2.2 GHz, and -21 dB return loss is from 2.85 to 2.95 GHz. The parametric study is performed to understand the characteristics of the proposed antenna. Also, good antenna performances such as radiation patterns and antenna gains over the operating bands have been observed and VSWR is 1.6 at 2.4 GHz.

Introduction
The wireless communication industry is integrating a number of services like Bluetooth, WLAN etc to the hand held communication devices. Therefore, in the present scenario, the bandwidth requirement of the antenna while maintaining the compactness becomes more critical. Transmission lines are energy guiding devices that can be used to transfer electromagnetic signal from one part of the system to another. The coplanar waveguide has made much attention in the high frequency researchers because of its attractive features. This paper presents the results of the investigations carried out to find the radiations characteristics or resonance phenomena in a finite ground coplanar waveguide fed strip monopole. The first part of this paper includes results of investigations carried out to study the behavior of a finite ground coplanar wave guide fed strip monopole while the second part of the paper provides the development of a T shape and L shaped monopole antenna from the strip monopole. A parametric study which depicts the effect of various antenna parameters is carried out and conclusions are made from the results. The analysis includes simulation studies using Ansoft HFSS and measured results with Vector Network Analyzer.

Monopole antennas have found widespread applications in wireless mobile communication systems. The increasing use of mobile communication systems has stimulated the interest in the dual-frequency monopole antennas for dual band operation. Numerous designs of dual-frequency compact monopole antennas have been reported, including the use of a center-fed monopole surrounded by multiple parasitic monopoles D. Liu [3], R. Schlub et al [4].

It is noted that the above mentioned monopole antennas are commonly mounted above a large ground plane and excited by a probe feed. Recently, the micro strip-line-fed technique has also been applied for designing dual frequency printed monopole compact antenna and reported in H. M. Chen [5] and F. S. Chang, S. H. Yeh, and K. L. Wong [6]. A monopole antenna fed by a coplanar waveguide (CPW) have been reported in Homg-Dean Chen et al [7]. CPW-fed antennas have many attractive features, such as no soldering points, easy fabrication and integration with monolithic microwave integrated circuits, and a simplified configuration with a single metallic layer. Thus, the designs of the CPW-fed antennas have recently received much attention.

Fuhl.J *et al.* [8] analysed the performance of a radiation coupled Dual L antenna, placed on the back side of the metallic housing of the handset, resulting in an improved radiation pattern pointing away from the user's head. The antenna was designed for operation in the GSM 900 frequency band. K.Hettak *et al.* [9] presented the design and experimental results of a coplanar waveguide (CPW) aperture coupled patch antenna for EHF band around 37 GHz. The antenna structure combined the advantages of CPW with those of aperture coupled Micro strip Antennas and also reduced the number of metal1ization levels. N.Chiba *et al.* [10] proposed a compact dual band internal antenna fed by a single feed, designed for the *90011800* MHz band. The antenna comprised of an outer $\lambda/4$ annular ring antenna with a short circuited plane and an inner $\lambda/4$ rectangular patch antenna, designed for the lower and higher resonant frequency respectively. The radiation patterns of the antenna were shown to be almost similar to that of a conventional $\lambda/4$ Micro strip antenna with a short-circuited plane.

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Design equations printed strip monopole

From the exhaustive experimental, FDTD computations and simulation studies the following design equation are derived for an optimized printed strip monopole. The resonant frequency (fr) of the monopole with dielectric constant (ε_r) and thickness of (h)

The Effective dielectric constant can be obtained by $\in_{eff} = \frac{\in_r + 1}{2}(1 + 0.3 * h)$

The Length of strip can be calculated by the equation

$$Ls = \frac{0.42 * c}{f_r * \sqrt{\in_{eff}}} \qquad (1)$$

The Width of Ground plane is obtained by the equation $W_g = \frac{1.38 * c}{f_r * \sqrt{\in_{eff}}}$ (2)

The Length of Ground plane is calculated by the equation (3), $Lg = \frac{0.36 * c}{f_r * \sqrt{\in_{eff}}}$ (3)

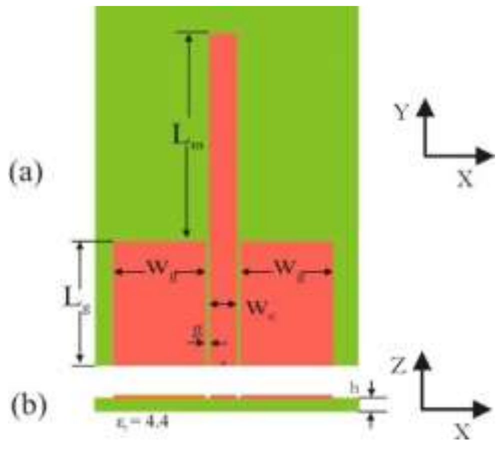
Resonant frequency (GHz), $f_r = 3 + \frac{2}{\sqrt{\in_{ref}}}\left[\frac{21}{Ls} + \frac{65}{Wg} + \frac{18}{Lg} - 3\right]$

The width of the monopole is set as width of 50Ω micro strip feed line. Since the field components are not confined to the substrate alone effective dielectric constant 'ε_{eff}' has to be used in calculation. Here 'c' is the velocity of electromagnetic wave in free space. The constants in the above equations are derived from exhaustive parametric analysis.

Antenna design

Monopole with feed length 21mm

The analysis of finite ground coplanar waveguide fed monopole antenna is presented in this session. The antenna consists of a coplanar wave guide designed for 50Ω input impedance, fed with an SMA connector. The center conductor of the FGCPW is extended to form a strip monopole of dimension 'Lm'. The initial design parameters for the FGCPW fed strip monopole antenna are, Lg = 19mm, Wg = 19mm, g = 0.35mm, Wc = 3mm and Lm = 21mm. The geometry of the strip monopole antenna is depicted in fig 1



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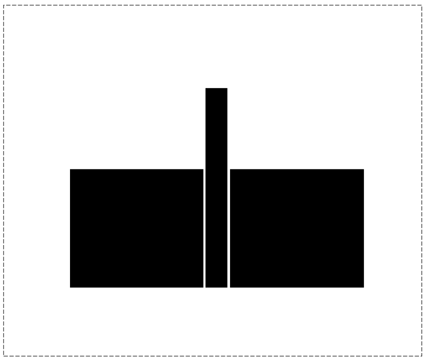

Fig1:Geometry of proposed antenna

L shape monopole

The analysis of finite ground coplanar waveguide fed monopole antenna is presented in this session. The antenna consists of a coplanar wave guide designed for 50Ω input impedance, fed with an SMA connector. The center conductor of the FGCPW is extended to form a strip monopole of dimension 'Lm'. The initial design parameters for the FGCPW fed strip monopole antenna are, L = 13mm, W = 3mm, gap between the ground plane and monopole = 0.35mm, W1 = 3mm, Lg=20mmand Wg = 20mm. The Fig.4 shows the Geometry of the Finite Ground Coplanar Waveguide Fed Strip Monopole Antenna. (L = 13mm, L1=16mm,W = 3mm, gap between the ground plane and monopole = 0.35mm, W1 = 3mm, Lg=20mmand Wg = 20mm, h=1.6mm and ε_r=4.4). The optimum parameters are obtained with the aid of Ansoft HFSSv12 software is shown in Fig.2.

Fig 2. Geometry of proposed L-Shaped antenna by Ansoft HFSS

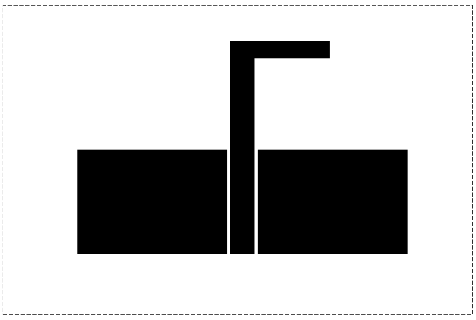

Fig 3 :Geometry of proposed L-Shaped antenna

T shape monopole

HFSS model of T shape monopole: The analysis of finite ground coplanar waveguide fed monopole antenna is presented in this session. The antenna consists of a coplanar wave guide designed for 50Ω input impedance, fed with an SMA connector. The center conductor of the FGCPW is extended to form a strip monopole of dimension 'Lm'. The initial design parameters for the FGCPW fed strip monopole antenna are, L = 23mm, W = 3mm, L1=19mm gap between the ground plane and monopole = 0.35mm, W1 = 3mm, LG=20mmand WG = 20mm. The geometry of the strip monopole antenna is depicted in fig.1

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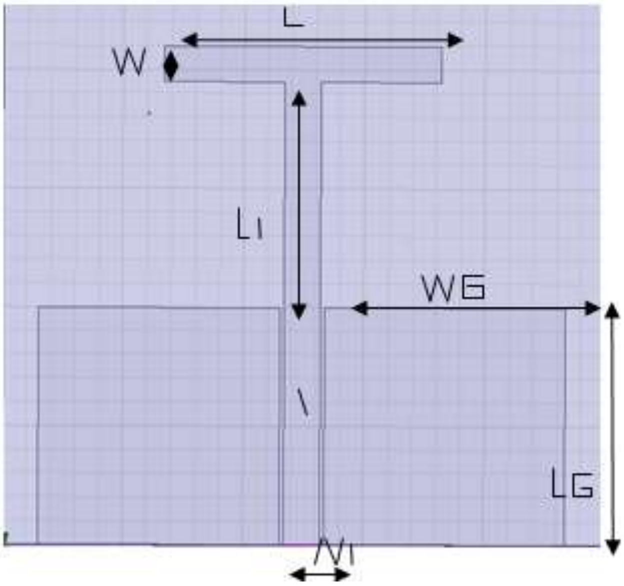
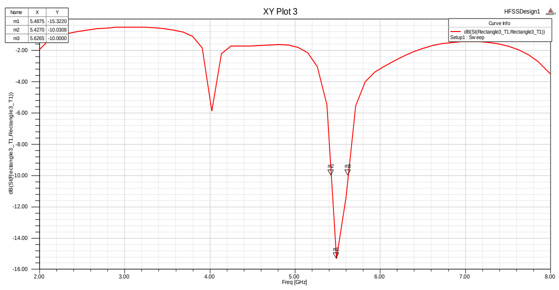


Fig4:Geometry of proposed T-Shape antenna

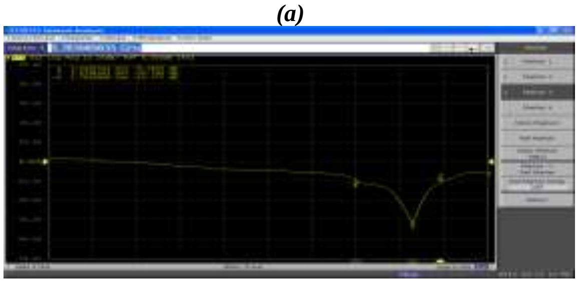
Geometry of the Finite Ground Coplanar Waveguide Fed Strip T-shape Monopole Antenna. (L = 23mm, L1=19mm, W = 3mm, gap between the ground plane and monopole = 0.35mm, W1 = 3mm, LG=20mm and WG = 20mm, h=1.6mm and εr=4.4) is shown in Fig.4. The optimum parameters are obtained with the aid of Ansoft HFSS.

Results

The micro strip monopole, L-Shape and T-Shape antennas are designed by Ansoft HFSS simulation software and fabricated on FR-4 substrate, the prototypes are tested on Vector Network Analyzer (VNA)-E5071C. The parameters like return losses and VSWR are presented for the optimized set of antenna parameters in Fig.5 to Fig 10.



(a)



(b)

Fig.5: a)Simulated Return loss characteristics(in Ansoft HFSSv12) b) Return loss characteristics by network analyzer for Monopole L=21mm

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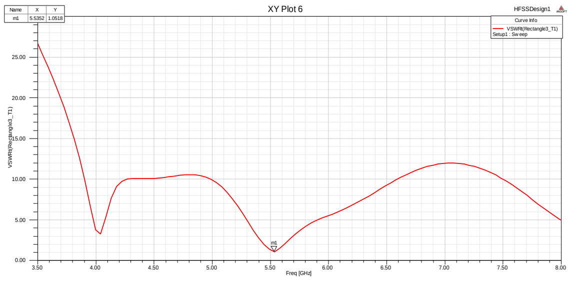
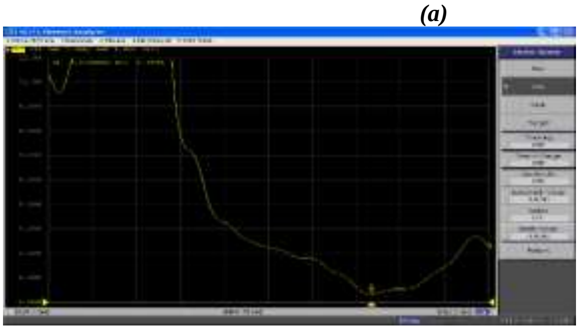


(a)

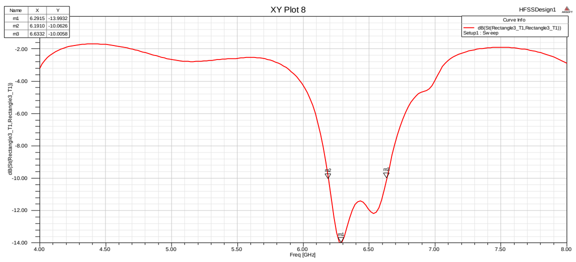


(b)

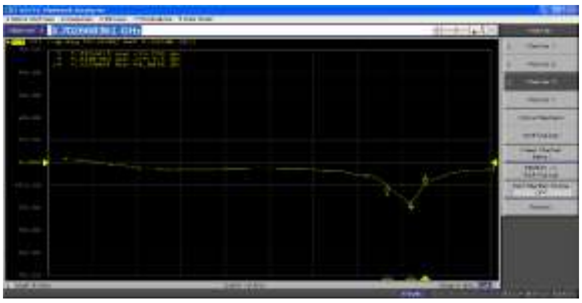
Fig6:a) Simulated VSWR characteristics b) VSWR characteristics by network analyzer for Monopole L=21mm

L shape monopole

The proposed antenna is simulated in Ansoft HFSS v12 software and fabricated and its practical results are obtained using Vector Network Analyzer (VNA)-E5071C



(a)



(b)

Fig.7 : a)Simulated Return loss characteristics(in Ansoft HFSSv12) b) Return loss characteristics by network analyzer for L-Shape

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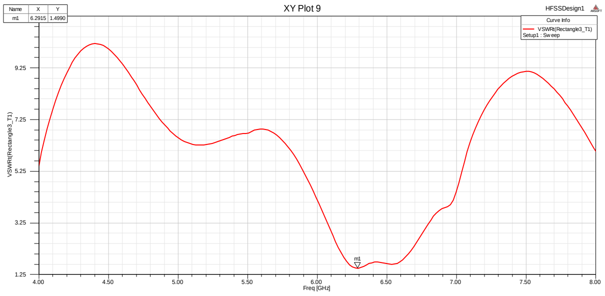
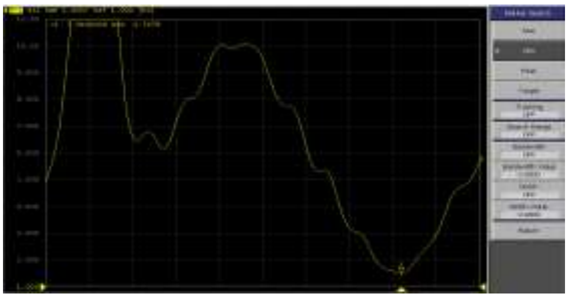


(a)



(b)

Fig 8: a) Simulated VSWR characteristics b) VSWR characteristics by network analyzer

T shape monopole

The proposed antenna is simulated in Ansoft HFSS v12 software and the results obtained are shown below,

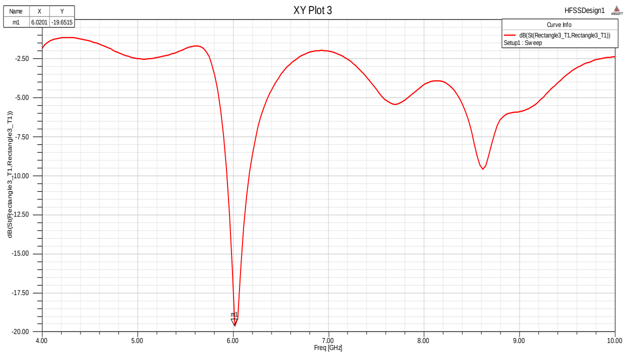


Fig.10 :Simulated Return loss characteristics(in Ansoft HFSSv12)

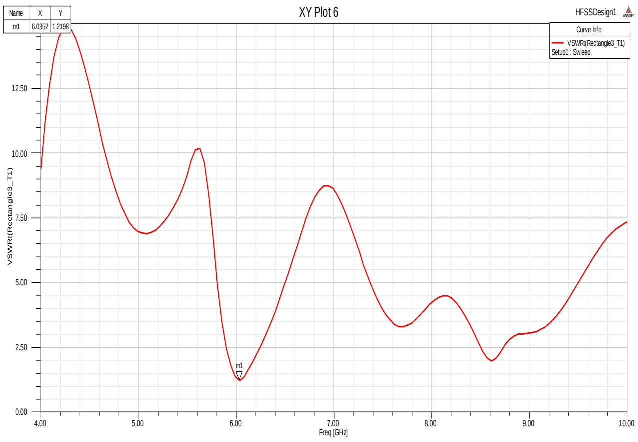


Fig11: Simulated VSWR characteristics

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The proposed antenna results obtained are shown below

Fig11: a)Proposed antenna testing by using Vector Network Analyzer(E5071C) b) ResonantbFrequency

Conclusions

A Finite Ground plane monopole antenna covering WiMAX and WLAN bands is proposed. The various parameters of the proposed antenna are optimized through simulation. Prototype of the proposed antenna has been designed, simulated in Ansoft HFSSv12 software and the fabricated Antenna is tested using Vector Network Analyzer (VNA).The practical return loss bandwidths observed in Vector Network Analyzer are observed monopole is resonating at 5.84GHZ GHz with the improvement of return loss. The proposed antenna provides In the United States, seven frequency bands have been allocated by the Federal Communications Commission for uses that include cordless phones 5.8 GHz (allocated in 2003 due to crowding on the 2.4 GHz band). These are: nearly Omni-directional radiation characteristics with moderate gain and efficiency which is suitable for the next generation wireless communication gadgets.

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