ISSN: 2278 – 1323
International Journal of Advanced Research in Computer Engineering & Technology (IJARCET)
Volume 5, Issue 12, December 2016

Study of CPW-Fed Antennas for WiFi and WiMAX Wideband Applications

Shaniya Qureshi, Anas Iqbal

***Abstract*— Compact coplanar waveguide (CPW) fed slot antenna for wideband (WB) applications of WiFi and WiMAX is presented in this paper. Many WB antennas have been developed to cover the wide operating bandwidth of the communication systems with acceptable performance. Currently, the prospective applications of WB technology are becoming clearer and clearer. The majority of WЬ R&D activities have been focused on how to meet the specific requirements of forthcoming WB systems. This paper will review the R&D of UWB antennas since 2002. Various slits on the ground plane is done for bandwidth enhancement. CPW fed slot antennas are attractive due to low dispersion and ease of integration with active and passive devices. CPW-fed slot antenna exhibit perfect impedance matching, broadside radiation patterns, and low cross polarization.**

***Index Terms*— Coplanar Waveguide Fed Antenna, Microstrip antennas, Slot antennas, WЬ antennas, WiFi and WiMAX Patch Antenna etc.**

I. INTRODUCTION

Wideband (WB) technology plays a vital role in the wireless communication world in recent years due to their great features such as low power consumption and high speed data rate. Slot antennas are currently under consideration for use in broadband communication systems due to their attractive features, such as wide frequency bandwidth, low profile, light weight, easy integration with monolithic microwave integrated circuit, low cost, and ease of fabrication [1]. These antennas have several advantages over common microstrip antennas as they provide good impedance matching, and bidirectional or unidirectional radiation pattern.

Slot antenna using CPW feeding mechanism provides several advantages over microstrip line feed, such as low dispersion, low radiation leakage, ease of integration with active devices [2]-[3]. When the antenna is fed by microstrip line, misalignment can result because etching is required on both sides of the dielectric substrate. Using CPW feeding technique alignment error can be eliminated. In CPW the conductor formed a center strip separated by a narrow gap from two ground planes on either side. Slot antenna results into wideband characteristic with CPW fed line having square slot [6] and CPW-fed hexagonal patch antennas [8] are demonstrated in the literature. In CPW-fed slot antenna by varying the dimensions of the slot and keeping it to the optimum value for wide bandwidth and proper impedance matching.

It has been observed by putting two rectangular slits on the ground plane of the CPW fed line results into dual band resonance in WЬ and bandwidth enhancement. Various patch shapes such as hexagon, T, cross, forklike, and square are used to give wide bandwidth [6-12]. The dimensions of the center strip, gap thickness and the permittivity of the dielectric substrate determine the effective dielectric constant and the characteristic impedance of line [16].

Wireless networks can operate in the same WЬ frequency. According to the FCC's order, any transmitting system which emits signals having a bandwidth greater than 500 MHz or 20% bandwidth can gain access to the WB spectrum.

II. ANTENNAS FOR WIFI AND WIMAX

As a matter of fact, the design and development of a single antenna working in two or more frequency bands, such as in wireless local area network (WLAN) or WiFi and worldwide interoperability for microwave access (WiMAX) is generally not an easy task. The IEEE 802.11 WLAN standard allocates

System	Designed Operating bands	Frequency Range (GHz)
WiFi IEEE 802.11	2.4 GHz	2.4-2.485
	5.2 GHz	5.15-5.35
	5.5 GHz	5.47-5.725
	5.8 GHz	5.725-5.875
Mobile WiMAX IEEE 802.16 2005	2.3 GHz	2.3-2.4
	2.5 GHz	2.5-2.69
	3.3 GHz	3.3-3.4
	3.5 GHz	3.4-3.6
	3.7 GHz	3.6-3.8
Fixed WiMAX IEEE 802.16 2004	3.7 GHz	3.6-3.8
	5.8 GHz	5.725-5.850

the license-free spectrum of 2.4 GHz (2.40-2.48 GHz), 5.2 GHz (5.15-5.35 GHz) and 5.8 GHz (5.725-5.825 GHz).

Table 1. Designed operating bands and corresponding frequency ranges of WiFi and WiMAX.

WiMAX, based on the IEEE 802.16 standard, has been evaluated by companies for connectivity, which can reach a theoretical up to 30 mile radius coverage. The WiMAX forum has published three licenses spectrum profiles, namely the 2.3 (2.3-2.4 GHz), 2.5 GHz (2.495-2.69 GHz) and 3.5

ISSN: 2278 – 1323
International Journal of Advanced Research in Computer Engineering & Technology (IJARCET)
Volume 5, Issue 12, December 2016

GHz (3.5-3.6 GHz) varying country to country. Many people expect WiMAX to emerge as another technology especially WiFi that may be adopted for handset devices and base station in the near future. The eleven standardized WiFi and WiMAX operating bands are listed in Table I.

Consequently, the research and manufacturing of both indoor and outdoor transmission equipment and devices fulfilling the requirements of these WiFi and WiMAX standards have increased since the idea took place in the technical and industrial community. An antenna serves as one of the critical component in any wireless communication system. As mentioned above, the design and development of a single antenna working in wideband or more frequency bands, called multiband antenna, is generally not an easy task. To answer these challenges, many antennas with wideband and/or multiband performances have been published in open literatures. The popular antenna for such applications is microstrip antenna (MSA) where several designs of multiband MSAs have been reported. Another important candidate, which may complete favorably with microstrip, is coplanar waveguide (CPW). Antennas using CPW-fed line also have many attractive features including low radiation loss, less dispersion, easy integration for monolithic microwave circuits (MMICs) and a simple configuration with single metallic layer, since no backside processing is required for integration of devices. Therefore, the designs of CPW-fed antennas have recently become more and more attractive. One of the main issues with CPW-fed antennas is to provide an easy impedance matching to the CPW-fed line.

III. WIDEBAND CPW FED SLOT ANTENNAS

A coplanar waveguide (CPW) is a one type of strip transmission line defined as a planar transmission structure for transmitting microwave signals. It comprises of at least one flat conductive strip of small thickness, and conductive ground plates. A CPW structure consists of a median metallic strip of deposited on the surface of a dielectric substrate slab with two narrow slits ground electrodes running adjacent and parallel to the strip on the same surface as shown in Fig 1. beside the microstrip line, the CPW is the most frequent use as planar transmission line in RF/microwave integrated circuits. It can be regarded as two coupled slot lines. Therefore, similar properties of a slot line may be expected.

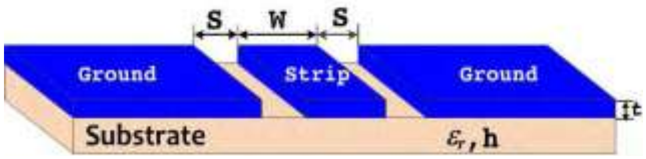
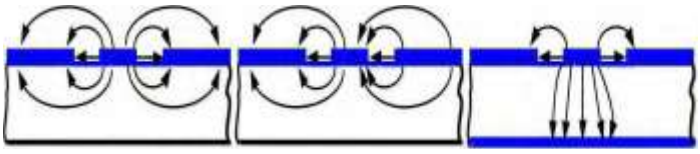


Fig 1. Coplanar waveguide structure (CPW)

The CPW consists of three conductors with the exterior ones used as ground plates. These need not necessarily have same potential. As known from transmission line theory of a three-wire system, even and odd mode solutions exist as illustrated in Fig. 2. The desired even mode, also termed coplanar mode [Fig. 2 (a)] has ground electrodes at both sides of the centered strip, whereas the parasitic odd mode [Fig. 2 (b)], also termed slot line mode, has opposite electrode potentials. When the substrate is also metallized on its bottom side, an additional parasitic parallel plate mode with zero cutoff frequency can exist [Fig. 2 (c)]. When a coplanar wave impinges on an asymmetric discontinuity such as a bend, parasitic slot line mode can be exited. To avoid these modes, bond wires or air bridges are connected to the ground places to force equal potential. Fig. 3. shows the electromagnetic field distribution of the even mode at low frequencies, which is TEM-like. At higher frequencies, the fundamental mode evolves itself approximately as a TE mode (H mode) with elliptical polarization of the magnetic field in the slots.



(a) (b) (c)

Fig.2. Schematic electrical field distribution in coplanar waveguide: (a) desired even mode, (b) parasitic odd mode, and (c) parasitic parallel plate mode.

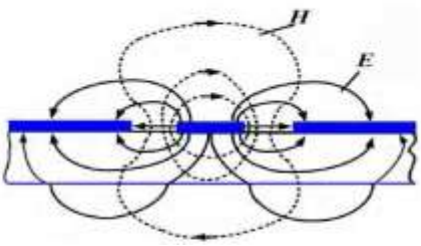


Fig. 3. Transversal electromagnetic field of even coplanar mode at low frequency.

To realize and cover WiFi and WiMAX operation bands, there are three ways to design antennas including (i) using broadband/wideband or ultrawideband techniques, (ii) using multiband techniques, and (iii) combining wideband and multiband techniques. For wideband operation, planar slot antennas are more promising because of their simple structure, easy to fabricate and wide impedance bandwidth characteristics. In general, the wideband CPW-fed slot antennas can be developed by tuning their impedance values. Several impedance tuning techniques are studied in literatures by varying the slot geometries and/or tuning stubs as shown in Fig. 4 and Fig. 5. Various slot geometries have been carried out such as wide rectangular slot, circular slot, elliptical slot, bow-tie slot, and hexagonal slot. Moreover, the impedance tuning can be done by using coupling mechanisms, namely inductive and capacitive couplings as shown Fig. 5. For capacitively coupled slots, several tuning stubs have been used such as circular, triangular, rectangular, and fractal shapes. In this section, we present the wideband slot antennas using CPW feed line. There are three antennas for wideband operations: CPW-fed square slot antenna using loading metallic strips and a widened tuning stub, CPW-fed equilateral hexagonal slot antennas, and CPW-fed slot antennas with fractal stubs[39].

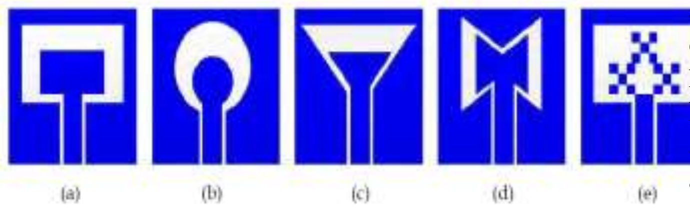


Fig. 4. CPW-fed slots with various slot geometries and tuning stubs (a) wide rectangular slot, (b) circular slot, (c) triangular slot, (d) bow-tie slot, and (e) rectangular slot with fractal tuning stub

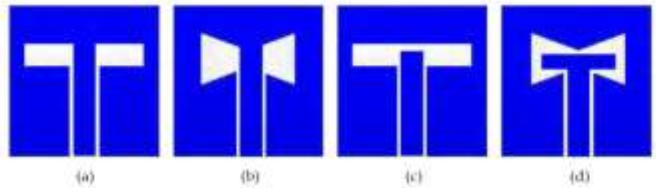


Fig. 5. CPW-fed slots with (a)-(b) inductive coupling and (c)–(d) capacitive coupling

IV. DESIGN EQUATIONS

After the proper selection of above three parameters, the next step is to calculate the radiating patch width and length.

Step 1: Calculation of Width (W)

For an efficient radiator, practical width that leads to good radiation efficiencies is:

$$W = \frac{1}{2f_r\sqrt{\mu_0\varepsilon_0}}\sqrt{\frac{2}{\varepsilon_r+1}} \qquad 1$$

where, μ_0 is the free permeability, ε_0 is the free space permittivity and ε_r is relative permittivity.

Step 2: Calculation of Effective Dielectric Coefficient (ε_{reff}) The effective dielectric constant is

$$\varepsilon_{reff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left[1+12\frac{h}{W}\right]^{1/2} \qquad 2$$

Step 3: Calculation of Effective Length (Leff)

The effective length is

$$L_{eff} = \frac{c}{2f_0\sqrt{\varepsilon_{reff}}} \qquad 3$$

Step 4: Calculation of Length Extension (ΔL)

$$\frac{\Delta L}{h} = 0.412\,\frac{(\varepsilon_{reff}+0.3)(\frac{W}{h}+0.264)}{(\varepsilon_{rff}-0.258)(\frac{W}{h}+0.8)} \qquad 4$$

Step 5: Calculation of actual Length of Patch (L)

The actual length of radiating patch is obtained by

$$L = L_{eff} - 2\Delta L \qquad 5$$

Step 6: Calculation of Ground Dimensions (Lg, Wg)

The transmission line model is applicable to infinite ground planes only. However, for practical considerations, it is essential to have a finite ground plane. The similar results for finite and infinite ground plane can be obtained if the size of the ground plane is greater than the patch dimensions by approximately six times the substrate thickness all around the periphery given as:

$$L_g = 6h + L\ ,\ W_g = 6h + W \qquad 6$$

V. CONCLUSION AND FUTURE WORK

CPW-fed proposed antenna exhibit low dispersion, ƅroadside radiation patterns and low cross polarization. The study of feeding techniques plays a vital role in field pattern and impedance matching concept. The dimension of the slot should ƅe less to obtain high efficiency and gain of an antenna. In future Wƅ antennas will ƅe strongly application driven tool in all commercial devices. As it is a challenging key to obtain wide ƅand of around 4 GHz while maintaining high efficiency and good impedance matching. Various appropriate design filters can ƅe integrated with Wƅ antenna as per impedance matching requirement.

REFERENCES

[1] H.-D. Chen, "ƅroadband CPW-fed square slot antennas with a widened tuning stub", IEEE Trans. Antennas Propag., vol. 51, no. 4, pp. 1982–1986, Aug. 2003.

[2]. J.-W. Niu and S.-S. Zhong, "A ƅroadband CPW-fed ƅow-tie slot antenna," in Proc. IEEE Antennas and Propagation Soc. Int. Symp, vol. 4, pp. 4483–4486, Jun.20–25, 2004.

[3]. Lin, Y.-C., and Hung, K.-J, "Compact ultra wideband rectangular aperture antenna and band-notched designs", IEEE Trans. Antennas Propag, 54, (11), pp. 3075–3081, 2006.

[4]. A. A. Dastrang, A. Imani, "Printed wide-slot antenna for wide band applications," IEEE Trans. Antennas Propag., vol. 56, no. 10, pp. 3097–3102, Oct. 2008.

[5]. H.D. Chen, "ƅroadband CPW-fed square slot antenna with a widened tuning stub," IEEE Trans. Antennas and Propag. Vol. 51, No 8, Aug 2003.

[6]. F. Consoli, F. Maimone, and S. ƅarbarino, "Study of a CPW-fed circular Slot antenna for UWƅ communications," Microwave and Optical Technology Letters, vol. 48, pp. 2272-2277,2006.

[7]. K. P. Ray and Y. Rang, "Ultrawideband printed elliptical monopole antennas," IEEE Trans. Antennas Propag., vol. 55, no. 4, pp. 1189–1192, 2007.

[8]. R. Chair, A. A. Kishk, and K. F. Lee, "Ultrawideband coplanar waveguide-fed rectangular slot antenna," IEEE Antennas Wireless Propag.Lett., vol. 3, pp. 227–229, 2004.

[9]. ƅ. K. Kormanyos, W. Harokopus, L. Katehi, and G. Reƅeiz, "CPW-fed active slot antennas," IEEE Trans. Microwave Theory Tech., vol. 42, pp. 541–545, Apr. 1994.

[10]. J.-Y. Sze, C.-I. G. Hsu, and S.-C. Hsu, "Design of a compact dual-band annular-ring slot antenna," IEEE Antennas Wireless Propag. Lett., vol.6, pp. 423–426, 2007.

[11]. H. L. Lee, H. J. Lee, J. G. Yook, and H. K. Park, "ƅroadband planar antenna having round corner rectangular wide slot," in Proc. IEEE Antennas and Propagation Society Int. Symp.,vol. 2, pp. 460–463, Jun. 16–21, 2002.

[12]. A. U. Bhobe, C. L. Holloway, and M. Piket-May, "CPW fed wide-band hybrid slot antenna," in Proc. IEEE Antennas Propag. Soc. Int. Symp. Dig, vol. 2, pp. 636–639.Jul. 2000.

[13]. Kang Ding, Yong-Xin Guo and Cheng Gao, "CPW-Fed Wideband Circularly Polarized Printed Monopole Antenna with Open Loop and Asymmetric Ground Plane", IEEE Antennas and Wireless Propagation Letters, June 25, 2016.

[14] Chaimool S., Akkaraekthalin P. and Krairiksh, M.," Wideband Constant beamwidth coplanar waveguide-fed slot antennas using metallic strip loading and a wideband tuning stub with shaped reflector", International Journal of RF and Microwave Computer – Aided Engineering, vol. 21, no 3, pp. 263-271, May 2011.

