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LITERATURE SURVEY OF MULTIBAND ANTENNA FOR WIRELESS APPLICATIONS

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ABSTRACT-An antenna that works on different standards is required to reduce cost and complexity. Thus multiband antenna that works in different frequencies of wireless standards is desired. The antenna discussed in this paper covers various frequency ranges for WLAN/WiMAX/GPS applications. It gives the understanding of radiation pattern for multiband wireless applications. It shows the importance of partial ground plane in antenna design. The impedance bandwidth, current distribution, radiation pattern, gain and efficiency of different antenna are reviewed.

Index Terms – Wi-Fi, WiMAX, WLAN, GSM 900, Bluetooth, GPS, Multiband

1 INTRODUCTION

Design of compact antennas that support different standards for wireless devices is an important topic of research in industry and academics. The antenna must operate in multiband; have wide bandwidth, compact size, easy to integrate with RF circuits. The center frequency for various wireless technology Wireless Local Area Network (WLAN) is at 2.4,5.2,5.8 GHz and that for Worldwide Interoperability for Microwave Access (WiMAX) is at 3.5, 5.5 GHz [4]. To satisfy WLAN/WiMAX/LTE/Wi-Fi standards, multiband antennas must operate at 2.4-2.484 GHz/5.15-5.825 GHz/5.25-5.85 GHz for WiMAX and 2.5-2.69 GHz for LTE [2] and 2.4-2.5 GHz/5.15-5.35 GHz/5.47-5.725 GHz/5.725-5.875 GHz for Wi-Fi [9].

This paper covers the literature survey for Wireless Fidelity (Wi-Fi), Worldwide Interoperability for Microwave Access (WiMAX), Global Positioning System (GPS), Global System for Mobile Communication 900 (GSM 900), Personal Communication Services (PCS).

2 LITERATURE SURVEY

Lev Pazin et al; RT Duroid 5880 no ground dielectric substrate is used. One radiating structure consists of T-shaped monopole that operates in two frequency bands. The other radiating structure is the slot formed by three metal parts such as inverted-L, right arm of the monopole T-shaped part, and ground plane. The driven monopole occupies an area of 7×45 mm^2. The antenna is resonant at three frequencies such as 2.5 GHz (2.39 – 2.52 GHz), 3.4 GHz (3.14 – 3.53 GHz) and 5.3 GHz (5.09 – 5.82 GHz). The length of the ground plane is 25 mm and it can be adjusted to provide better impedance matching. The radiation pattern of the E-field is nearly omnidirectional.

Jing Pei et al; Radiating element consists of circular ring and Y-shaped like strip. The width and length of 50 ohm microstrip feed is 2.4 mm and 12.06 mm. Cambered ground plane is used at the back side of ground plane. Isosceles triangle is etched in the ground plane under the microstrip feed for impedance matching. The gap between the circular ring and the arc shaped strip affects the impedance performance and resonant frequencies of the antenna. The defected ground plane acts as a filter to remove unwanted frequencies. By adding a Y-shaped strip the antenna resonates at dual band such as 2.58 GHz (2.46-2.63 GHz), 3.58 GHz (3.15-5.58 GHz). The radiation pattern in the H-plane is omnidirectional and that in the E-plane is monopole like.

RANGE	RESONANT FREQ	BANDWIDTH	RETURN LOSS
2.4-2.7 GHz	2.61 GHz	300 MHz	-31 dB
3.1-4.15 GHz	3.5 GHz	1050 MHz	-27 dB
4.93-5.89 GHz	5.4 GHz	960 MHz	-37 dB

Wen-Chung Liu et al; Slots are used in the ground plane to excite the resonant modes and improve the impedance matching. The obtained bandwidth covers the WLAN standards (2.4/5.2/5.8 GHz) and WiMAX standard (3.5/5.5 GHz). Without using defected ground plane antenna is not matched. With the use of L-shaped strips improves impedance matching and excite additional resonance. Radiation pattern is nearly omnidirectional. With the increase in operating band, efficiency increases but the directivity decreases because current in lower frequency is more in-phase and concentrated in the same direction for high directivity.

RANGE	RESONANT FREQ	BANDWIDTH	EFFICIENCY	DIRECTIVITY	GAIN
2.13-2.51 GHz	2.26 GHz	380 MHz	60 %	4.7 dB	2.46 dBi
3.26-3.83 GHz	3.6 GHz	570 MHz	62 %	4.1 dB	2.45 dBi
5.03-5.91 GHz	5.3 GHz	880 MHz	72 %	3.8 dB	3 dBi

Abdolmehdi Dadgarpour et al; Slotted ground plane is used to increase the resonant frequencies. The proposed antenna can support following standards when -10 dB is used as reference PCS, 2.4/5.5 GHz WLAN, Bluetooth, 2.5/3.5/5.5 GHz WiMAX, HIPERLAN 2/IEEE 802.11 a. When -6 dB is used as reference the antenna covers DCS band (1.71-1.88 GHz). Parametric analysis is used to find the effect of ground length on the resonant frequencies. Radiation efficiency is more than 80% in all investigated bands. There is no deep null in any direction. This is an important factor while choosing an antenna for mobile devices because null in any direction cause signal drop-out in that direction. To prevent undesired direction, the radiation pattern must be omnidirectional and 8-shaped pattern. The maximum gain at 1.9 GHz and 5.5 GHz is 0.3 dBi and 2.2 dBi. These values indicate the omnidirectional performance of the antenna.

Ming-Tien Wu et al; Resonance antennas such as half-wave dipole or quarter-wave monopoles has small bandwidth. A bow-tie antenna is a taper-shaped antenna for broadband applications. The bandwidth of a bow-tie antenna can be controlled by tuning the included angle. Bandwidth is directly proportional to included angle. Horizontal slots of different lengths are etched to create bent monopole. The length of the bent monopole is quarter wavelength. The width of the bent monopole can be adjusted to tune the bandwidth. The bandwidth of the bent monopole is larger than the single monopole for the same operating frequency because the bow-tie patch near the CPW feed points acts as broadband matching structure. The width and length of the 50 ohm microstrip feed is 2.5 mm and 45 mm.

RANGE	RESONANT FREQ	PEAK GAIN	RADIATION EFFICIENCY
2.17 to 2.72 GHz	2.5 GHz	3.75 dBi	87.51 %
3.34 to 3.66 GHz	3.5 GHz	3.56 dBi	81.08 %
4.85 to 5.77 GHz	5.5 GHz	3.93 dBi	80.33 %

Mahdi Moosazadeh et al; Microstrip fed monopole antenna is designed for triple band operation. The triple band is achieved by loading a pair of symmetrical L and U shaped slots inside the patch. The length of the slots is taken in such a way that the total length of the three combinations is equal to the quarter of the guide wavelength at the desired frequency. The width and length of the 50 ohm microstrip feed is 2 and 7.2 mm. It is expected that the far-field radiation pattern of the antenna will be omnidirectional because the patch with slots is small and it is backed by partial ground plane. Parametric study of the length of the ground plane and width of the substrate is performed to obtain desired frequency band and impedance matching. The radiation pattern of the proposed antenna is omnidirectional in H-plane and bidirectional in E-plane.

RANGE	RESONANT FREQ	BANDWIDTH	GAIN
2.39-2.69 GHz	2.42 GHz	300 MHz	2-2.6 dBi
3.4-3.85 GHz	3.7 GHz	450 MHz	2.6-3.2 dBi
4.55-7.85 GHz	5.7 GHz	3300 MHz	2.5-3.8 dBi

Hattan F. Abutarboush et al; The radiating part consists of rectangular patch, 50 ohm microstrip feed line and ground plane. A monopole antenna is designed at 3.7 GHz. An inverted T-shaped slot is used in the partial ground plane to disturb the current flow and to make the current path longer. Thus the antenna resonates at dual frequency. The frequency shifts from 3.6 GHz to 4.25 GHz and other resonant frequency is 1 GHz. Two vertical slots are used at the both sides of the inverted T shaped slot to form E-shaped slot. The frequency shifts from 1 GHz to 0.94 GHz. The antenna resonates at 0.94, 2.7, 4.75 GHz. The wavelength at the resonant frequency is $\frac{\lambda_0}{\sqrt{\frac{\varepsilon_r+1}{2}}}$ where, λ_0 is the free space wavelength.

RANGE	RESONANT FREQ	BANDWIDTH	RADIATION EFFICIENCY	PEAK GAIN
912-972 MHz	0.94 GHz	60 MHz	55 %	3.67 dBi
2.390-3.943 GHz	2.8 GHz	1553 MHz	-	-
4.689-5.324 GHz	5 GHz	635 MHz	82 %	1.34 dBi
-	3.25 GHz	-	72 %	4.94 dBi

Wei-Mei Li et al; The width of the 50 ohm microstrip feed is 3.8 mm. Antenna 1 consists of single metallic layer with asymmetric U-shaped slot. If the size of the slot is properly selected then two orthogonal modes with same amplitude and 90^0 phase difference are produced to create dual-band circular polarization. Antenna 2 consists of rectangular slot and it is loaded with U-shaped strip which is rotated by 45^0. The offset feed provides 90^0 phase difference.

	RESONANT FREQ	BANDWIDTH (BW)	3dB AXIAL RATIO BW
ANTENNA 1	2.6 GHz	114 MHz	540 MHz
	3.6 GHz	158 MHz	450 MHz
ANTENNA 2	2.5 GHz	-	180 MHz
	3.5 GHz	-	114 MHz

For U-shaped slot antenna, axial ratio bandwidth is greater than impedance bandwidth because of high efficiency of U-shaped slots to generate orthogonal modes. The radiation mechanism of two antennas is different. Peak gain for antenna 1 is 2.92 dBi and that of antenna 2 is 4.51 dBi.

Y.F Cao et al; The GPS systems use circularly polarized signal with a frequency band from 1570 MHz to 1590 MHz but most wireless devices uses linearly polarized antenna to receive GPS signal. This will lead to -3 dB power loss which is acceptable by wireless device designers. The size of the ground plane affects the antenna performance. The resonant frequency can be determined by the slot dimension and it is given by f = $\frac{c}{2(L+W)\sqrt{\epsilon}}$ where ε is the effective dielectric constant and it is approximately calculated by $\frac{\epsilon_r+1}{2}$, where ϵ_r is the relative permittivity of the substrate, c is the speed of light in free space, L and W is the length and width of the rectangular slot.

Feed cable is covered by EM suppressant tubing to absorb unwanted radiation. But this reduces the gain and efficiency of the antenna. The antenna efficiency is calculated by $\frac{G(\theta,\varphi)(1-\rho^2)}{D(\theta,\varphi)}$ where ρ is the voltage reflection coefficient. G (θ,φ) and D (θ,φ) is the gain and directivity of the antenna as function of spherical coordinates θ,φ.

RANGE	RESONANT FREQ	BANDWIDTH	EFFICIENCY
1.575-1.665 GHz	1.575 GHz	90 MHz	76.8 %
2.4-2.545 GHz	2.45 GHz	145 MHz	80.1 %
3.27-3.97 GHz	3.5 GHz	700 MHz	96.6 %
5.17-5.93 GHz	5.2 GHz	760 MHz	85.5 %

3 CONCLUSION

The following table shows the substrate properties and the application covered used in different literatures.

REFERENCE	SUBSTRATE	DIELECTRIC CONSTANT	THICKNESS	DIMENSIONS	APPLICATIONS
[9]	RT5800	2.2	0.127 mm	7×45 mm²	Wi-Fi(2.4/5 GHz), WiMAX(3.5 GHz)
[6]	FR4	4.4	1.59 mm	38×25 mm²	WLAN/WiMAX
[7]	FR4	4.4	1.6 mm	-	WLAN(2.4/5.2/5.8 GHz), WiMAX (3.5/5.5 GHz)
[8]	FR4	4.4	1.6 mm	40×30 mm²	PCS,WLAN(2.4/5.5 GHz), Bluetooth,WiMAX (2.5/3.5/5.5 GHz)
[1]	FR4	3.5	0.8 mm	48×18 mm²	GPS/WLAN/WiMAX (IEEE 802.11 a/b/g)
[2]	FR4	4.2	0.8 mm	-	WLAN/WiMAX/LTE
[4]	FR4	4.4	1.6 mm	15×15 mm²	WiMAX/WLAN
[5]	FR4	4.4	1.57 mm	30×40 mm²	GSM 900/Bluetooth/WLAN/WiMAX/S-DBM

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