ISSN: 2229-6948(ONLINE)
DOI: 10.21917/ijct.2012.0080

DESIGN OF MULTIPLE PRINTED DIPOLE ANTENNAS IN DIFFERENT CONFIGURATION FOR WIRELESS COMMUNICATION APPLICATIONS

C. Poongodi[1] and A. Shanmugam[2]
[1]*Department of Information Technology, Bannari Amman Institute of Technology, India*
E-mail: poongi_cj@yahoo.co.in
[2]*Bannari Amman Institute of Technology, India*
E-mail: dras_bit@yahoo.com

Abstract
A printed dipole antenna for wireless communication applications is designed and simulated using ADS software. This paper presents the simulated results of array of printed dipole antennas for different configuration which are used in the MIMO systems. The antenna is designed and characterized by measuring return loss, directivity, gain and radiation pattern. It also presents the channel capacity of MIMO system and single antenna system.

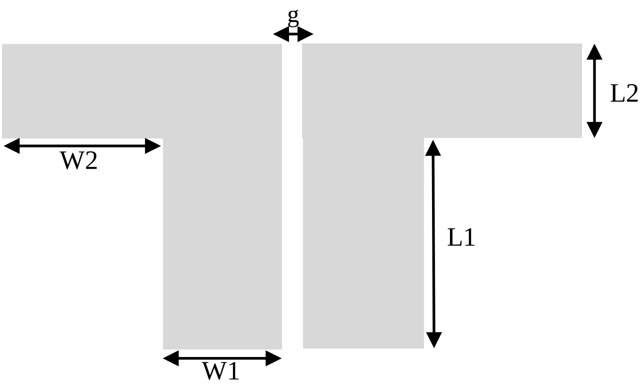
Keywords:
Printed Dipole, Dipole Configurations, Capacity, MIMO

1. INTRODUCTION

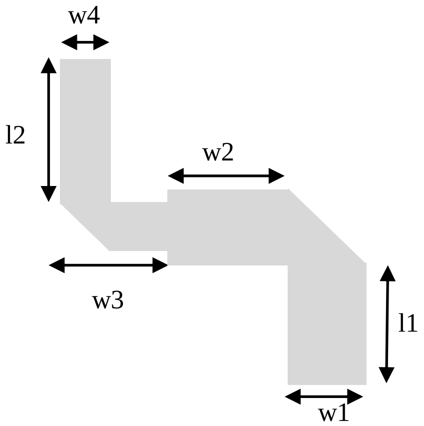
The demand for spectral efficiency in wireless communication is ever increasing. It has been established in [1] that using antenna arrays at the transmitter and the receiver can increase the capacity and it is proportional to minimum of number of transmitting elements and number of receiving elements. The capacity depends mainly on the channel and the antenna characteristics. The capacity can be improved by proper design of antenna elements [2] and choosing appropriate array configuration [3]. Multiple-Input Multiple-Output (MIMO) wireless systems have demonstrated the potential to increase communication spectral efficiency in a rich multipath environment. From an antennas perspective, different array configurations and types of element have been proposed and analyzed for MIMO links. Therefore it is important to know how various array configurations are performing in the case of MIMO system. In recent years, wireless local area networks (WLANs) and the WiMAX technology have been widely used in commercial, medical and industrial application. WLAN is one of the most important areas of wireless communication. WLAN takes advantage of license free frequency bands, industrial, scientific and medical (ISM) bands and uses both 2.412 to 2.482GHz (IEEE 802.11b and IEEE 802.11g) and 5.15 to 5.825GHz (IEEE 802.11a) frequency bands [4]. Several printed antennas for WLAN applications have been reported in the literature [5-7]. Dual-band antennas without balun proposed in [6-8] are unsuitable for connection to a singled transceiver. In this paper, a dual-band printed dipole antenna integrated with balun [9] has been presented. The printed dipole antenna with integrated balun can be matched to a 50Ω feed simply through an adjustment of the feed point of the integrated balun. Because the position of the feed point is an adjustable parameter, the adjusted integrated balun may match to different impedance values, which is useful for antenna arrays because the mutual coupling between array elements may change the input impedance of each antenna element. MIMO antennas are suitable for the 4th generation mobile communication systems requiring high speed and high quality transmission involving large amount of data transfer. The use of MIMO technology in small terminals causes high degree of coupling and spatial correlation between antenna elements thus affecting the MIMO channel capacity. The primary aim of MIMO antenna design is to reduce correlation between received signals. Higher mutual coupling may result in lower antenna efficiencies and higher correlation coefficients [10]. The spacing between the antenna elements should be at least one half wavelengths to reduce mutual coupling and correlation. In this article array of printed dipole array also presented for potential use in wireless communication. The dipoles are fed through a microstrip balun. Advantages of the printed dipole antennas are low cost, compact size, ease of fabrication and low profile [11]. The channel capacity of MIMO system for two element side by side array configuration with and without mutual coupling is also incorporated in the simulation.

2. ANTENNA DESIGN AND STRUCTURE

The antenna is designed on a substrate of thickness, h = 14mm with dielectric constant, ϵr = 4.5. A dipole antenna usually needs a balanced feed for practical operation. The electric field of microstrip lines is mainly normal to the substrate; however the electric field across the gap between the arms of the dipole is along its length, thus, the dipole cannot be fed directly from a microstrip line. This requires alternative feeding mechanisms, for example co planar strips or microstrip to slot line cross junction. We chose to excite the dipole with a printed balun [12]. A balun is a device used to balance an unbalanced transmission line. The printed dipole with the integrated balun features a broadband performance [13] and has found applications in wireless communications [14] and antenna arrays [15]. For simulation the length of the designed antenna, L = 35 mm and width, W = 55 mm, space between dipole arm is g = 1mm. Fig.1 shows geometry of a printed dipole antenna with adjusted integrated balun. The geometry size of dipole arm and balun is shown in Table.1. In MIMO systems multiple printed dipole antennas are used. The antenna array configurations investigated in this paper are: side by side, Echelon and H shaped array antennas. Fig.2 shows side by side array configuration of four element array. Echelon and H-shaped printed dipole antenna arrangements are shown in Fig.3 and Fig.4 respectively. The side by side and echelon configurations have their elements oriented in the vertical direction; they provide only space diversity [14] unlike H shaped arrays. In H shaped configuration elements are oriented in both vertical and horizontal direction and hence it provides dual polarized characteristics.



(a)



(b)

Fig.1. Configuration of the printed dipole antenna
(a) Radiating element (b) Balun

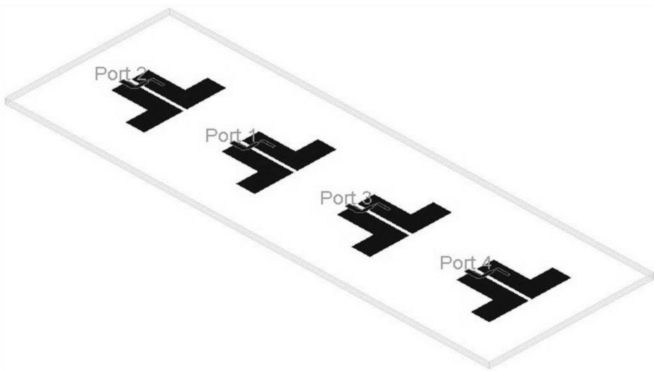


Fig.2. Multiple printed dipole antenna in side by side array configuration

Table.1. The designed geometry size of printed dipole and Balun

Dipole arm		Balun	
Parameter	**Value**	**Parameter**	**Value**
L1	23mm	l1	7.6mm
L2	12mm	l2	7mm
W1	11mm	w1	2.8mm
W2	14mm	w2	5mm
g	1mm	w3	4mm
Overall dimension	$35*55mm^2$	w4	1.6mm

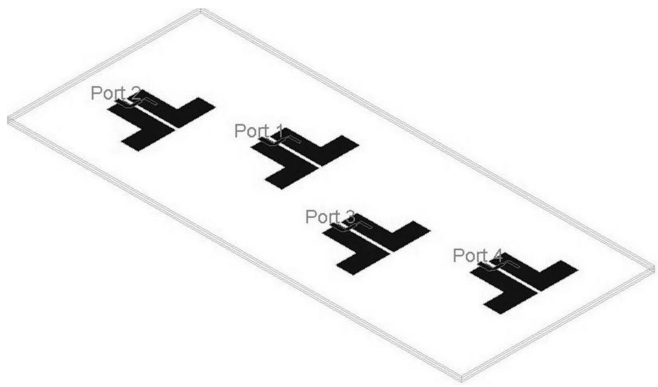


Fig.3. Multiple printed dipole antenna in Echelon configuration

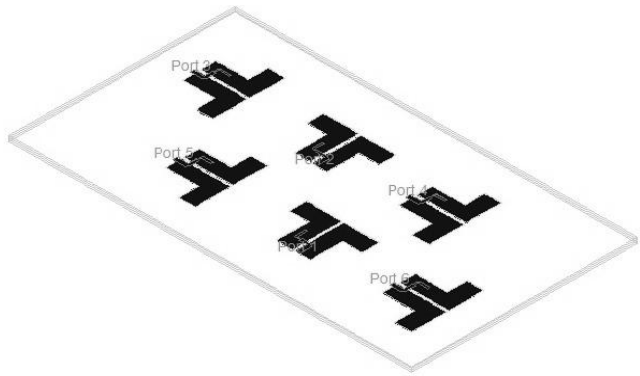


Fig.4. Multiple printed dipole antenna in H-shaped configuration

3. RESULTS AND DISCUSSION

The simulation of the design is carried out by the method of moment's technique using ADS software [16]. The radiation pattern of the single printed dipole antenna is shown in Fig.5. Fig.6 gives the simulated return loss of the echelon antenna which is -35dB at 6GHz. The circularly polarized electric field pattern is shown in Fig.7. The simulated gain and directivity of this echelon antenna is shown in Fig.8 which clearly indicates that maximum gain is 9.18dB. Fig.9 shows return loss of H-shaped antenna which is -29dB at 4.6GHz. The gain and directivity of the H-shaped antenna is 6.43 at 4.6GHz. Fig.10 shows electric current distribution of array antenna. The gain, directivity, return loss and efficiency of different antenna configurations are shown in Table.2. Here 2*2 array configurations give better gain and directivity. So the theoretical capacity with mutual coupling for 2*2 array configuration has been evaluated based on Monte Carlo realizations by constructing the channel matrix with Gaussian distributed uncorrelated random variables.

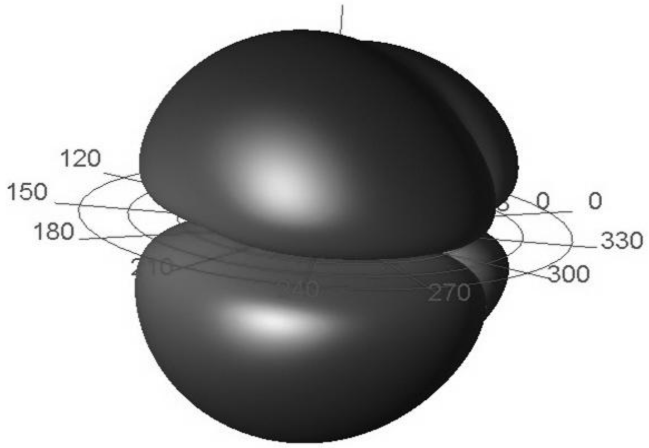


Fig.5. Radiation pattern of single printed dipole antenna

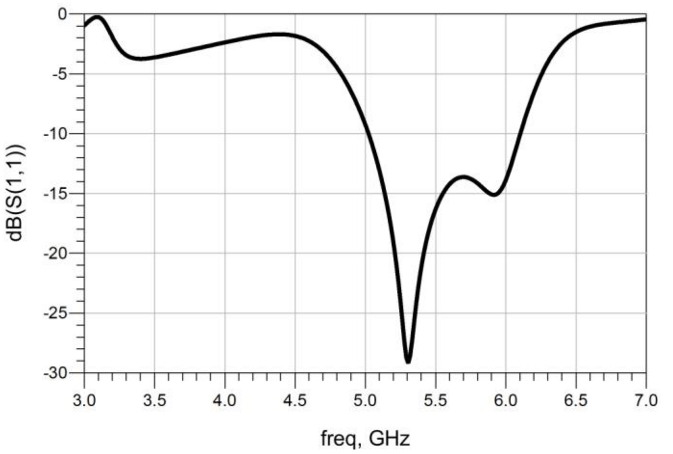


Fig.6. Simulated return loss of the single printed dipole antenna

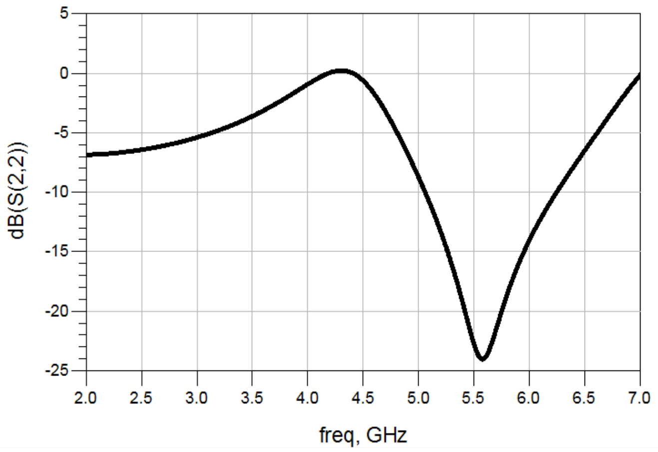


Fig.7. Simulated return loss of the multiple side by side printed dipole antenna

The mutual coupling between antenna elements is computed from the measured S parameters. 10^4 Monte Carlo runs were performed to compute the average capacity. The receiver signal-to-noise ratio (SNR) was varied from 3 to 12dB. Fig.11 compares ergodic capacity of single input single output antenna with multiple 2*2 array type printed dipole antenna with and without mutual coupling. The use of multiple antennas in a communication link greatly improves the spectral efficiency of the system [12].

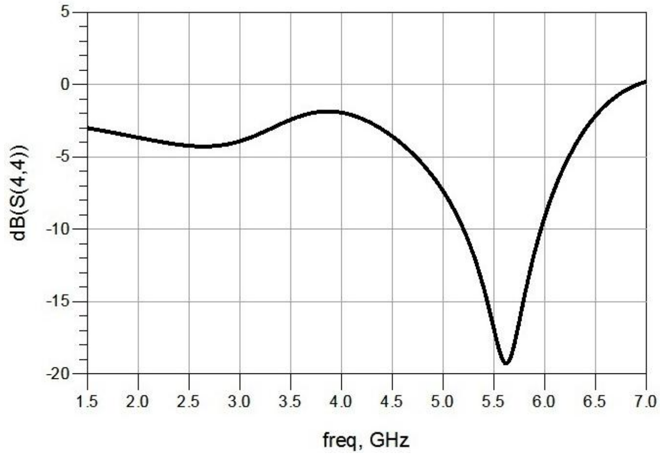


Fig.8. Simulated gain and directivity of echelon antenna

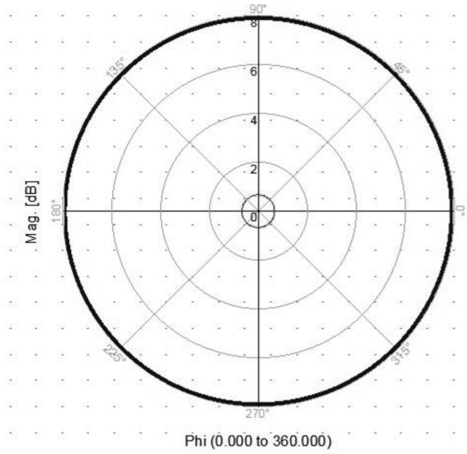


Fig.9. Simulated return loss of the H-shaped antenna

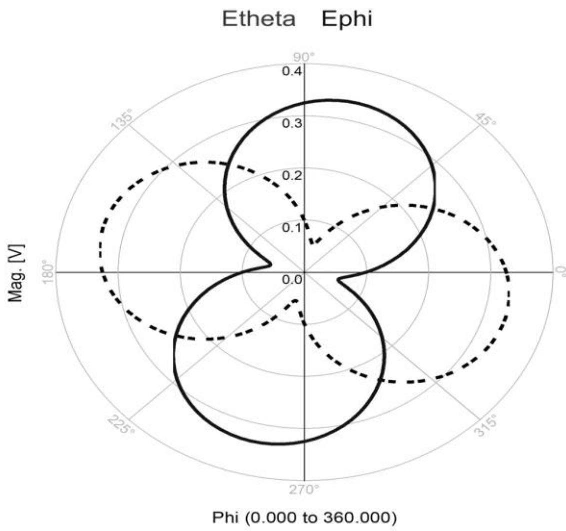


Fig.10. Electric current distribution of 2*2 array antenna

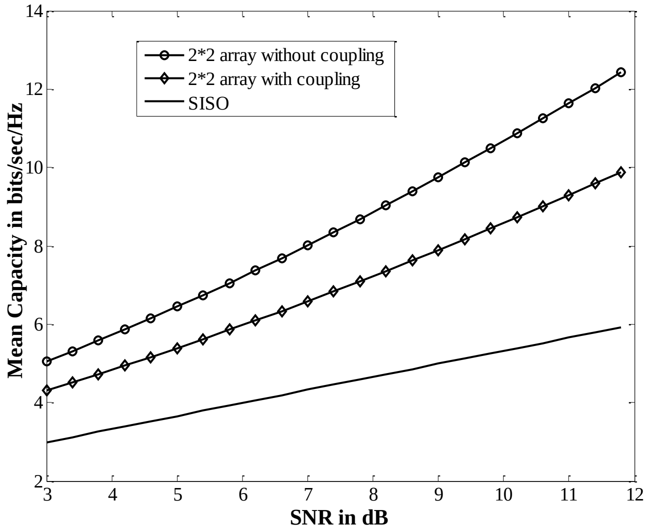


Fig.11. Mean capacity as a function of SNR for different antenna configurations

Table.2. Simulated results of printed dipole antenna in different configuration

Antenna type	Gain (dBi)	Directivity (dBi)	Radiated power (mW)	E_θ(max)	E_ϕ(max)
Single printed dipole	3.56	3.57	1.20	0.325	0.403
2 element array	5.92	6.38	4.38	0.319	1.020
4 element side by side array	8.85	8.85	18.9	0.761	2.828
Echelon array	8.93	8.93	20.04	1.731	2.514
H-shaped array	8.98	8.98	43.42	1.779	4.173

4. CONCLUSION

A printed dipole with an adjusted integrated balun is developed. The antenna has small size and easy to integrate with circuit on the same dielectric, resulting in the reduction of, fabrication cost and required volume of whole system. With a help of printed antenna an echelon, side by side array and H-shaped array antenna has been developed and analyzed. This array antenna nearly produces an omnidirectional radiation pattern, so this array seems to be a good antenna for wireless applications. Finally in this paper the capacity of 2*2 array with and without mutual coupling is evaluated using Monte Carlo simulations and compared with the single input single output antenna (SISO) system.

ACKNOWLEDGEMENT

This work was supported by the All India Council for Technical Education–Research Promotion Scheme of India.

REFERENCES

[1] G. J. Foschini and M. J. Gans, "On Limits of Wireless Communications in a Fading Environment when Using Multiple Antennas", *Wireless Personal Communications*, Vol. 6, No. 3, pp. 311-335, 1998.

[2] C. Waldschmidt, T. Fugen and W. Wiesbeck, "Spiral and dipole antennas for indoor MIMO-systems", *IEEE Antennas Wireless Propagation Letters*, Vol. 1, No. 1, pp. 176–178, 2002.

[3] C. C. Martin, J. H. Winters and N. R. Sollenberger, "MIMO radio channel measurements: Performance comparison of antenna configurations", *IEEE VTS 54th Vehicular Technology Conference*, Vol. 2, pp. 1225–1229, 2001.

[4] Zhijun Zhang, M. F. Iskander, J. C. Langer and J. Mathews, "Dual-Band WLAN Dipole Antenna Using an Internal Matching Circuit", *IEEE Transactions on Antennas and Propagation*, Vol. 53, No. 5, pp. 1813-1818, 2005.

[5] H. M. Chen, J. M. Chen, P. S. Cheng and Y. F. Lin, "Feed for dual-band printed dipole antenna", *Electronics Letters*, Vol. 40, No. 21, pp. 1320-1322, 2004.

[6] S. Y. Suh, A. E. Waltho, L. Krishnamurthy, D. Souza, S. Gupta, H. K. Pan and V. K. Nair, "A miniaturized dual-band dipole antenna with a modified meander line for laptop computer application in 2.5 and 5.5GHz WLAN band", *IEEE Antennas and Propagation Society International Symposium*, pp. 2617-2620, 2006.

[7] S. W. Su and J. H. Chou, "Low cost at metal-plate dipole antenna for 2.4/5GHz WLAN operation", *Microwave and Optical Technology Letters*, Vol. 50, No. 6, pp. 1686-1687, 2008.

[8] V. Trifunovic and B. Jokanovic, "Review of printed Marchand and double Y baluns: Characteristics and application", *IEEE Transactions on Microwave Theory and Techniques*, Vol. 42, No. 8, pp. 1454-1462, 1994.

[9] A. R. Mallahzadeh, S. Es'haghi and A. Alipour, "Design of an E-shaped MIMO antenna using IWO algorithm for wireless application at 5.8GHz", *Progress in Electromagnetics Research*, Vol. 90, pp. 187-203, 2009.

[10] X. Li, L. Yang, S. X. Gong and Y. J. Yang, "Dual-Band and Wideband design of a printed dipole antenna integrated with dual band balun", *Progress in Electromagnetics Research Letters*, Vol. 6, pp. 165-174, 2009.

[11] E. Michailidis, C. Tsimenidis and G. Chester, "Printed dipole array for MIMO wireless networks", *Proceedings of IEEE Loughborough Antennas and Propagation Conference*, pp. 117–120, 2007.

[12] B. Edward and D. Rees, "A broadband printed dipole with integrated balun," *Microwave Journal*, Vol. 30, pp. 339-344, 1987.

[13] H. R. Chuang and L. C. Kuo, "3-D FDTD design analysis of a 2.4-GHz polarization-diversity printed dipole antenna with integrated balun and polarization-switching circuit for WLAN and wireless communication applications", *IEEE Transactions on Microwave Theory and Techniques*, Vol. 51, No. 2, pp. 374-381, 2003.

[14] J. P. R**.** Bayard, "Analysis of infinite arrays of microstrip-fed dipoles printed on protruding dielectric substrates and covered with a dielectric radome", *IEEE Transactions on Antennas and Propagation*, Vol. 42, No. 1, pp. 82-89, 1994.

[15] Advanced Design System–ADS 2011.01, Agilent Technologies, Inc. 2000-2011.