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Bending Effect on Body Wearable Microstrip Patch Antenna

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Abstract— A body wearable antenna is supposed to wear on body. It is not possible to keep this antenna in flat condition on different parts of body. It may be subjected to deformation/bending due to movement of body part on which it is mounted. It is expected that the performance of antenna should not change drastically with amount of bending/deformation. So a wearable antenna should also perform efficiently even in bending condition also. In this paper a body wearable antenna has been designed using polycot textile substrate of 3 mm having dielectric constant of 1.48 operating at 2.4 GHz resonant frequency used for ISM band. Bandwidth and S-parameter of antenna having a polycot material (combination of curtain cotton and polyester) as a substrate is measured. Gain and directivity of same antenna has been observed in flat as well as bending condition.

Keywords—ISM band, body wearable, bending effect, textile material.

I. INTRODUCTION

To monitor different bio-signals of human body and transmitting these signals for further analysis about his medical states body wearable antenna is being proposed in literature. Wearable antenna is an application-oriented and fast growing field in research. It is one of the special type of patch antenna in which solid substrate of patch antenna is replace by flexible textile to make more flexible when antenna is required to worn on body [1-4]. For sensing and processing purposes antenna may be integrated in garments which increase the security and comfort to the users. In this way, wearable antenna play very important role in wireless body area network [5-7]. These types of antennas provide the continuous information about the person's state of health by monitoring and transmitting the bio-signals of that person. For this communication an antenna is required to transmit the signals [7-9]. So instead of using a metal antenna a worn textile may be used as a transmitter or receiving antenna. Human body is having a number of bends due to the curved shape of body. Due to good elasticity and excellent flexibility textile materials are well adaptable on these curved surfaces [9-12]. But sometime due to curved surface the electromagnetic properties are changed and affect the antenna performance. Due to bending and elongation of the fiber, the thickness and permittivity is changed. Change in thickness and permittivity further affects the antenna bandwidth and resonance frequency [13,14].

II. DESIGN OF ANTENNA

Basic parameters for designing of a microstrip patch antenna are resonant frequency; dielectric constant and thickness of substrate are given in table 1. Using these parameters length and width of patch are calculated as below [1].

Calculation of the Width of patch (W): The width of patch is given by

$$W = \frac{c}{2f_r}\sqrt{\frac{2}{\varepsilon_r+1}} \qquad (1)$$

Where, c is free space velocity of light. f_r is resonant frequency and is 2.4 GHz for the current design. Due to presence of air between the patch and dielectric the permittivity is changed and known as effective permittivity (ε_{reff}) and given by

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

Where, h is height or thickness of the substrate.
Calculation of the length extension ΔL, which is given by

$$\frac{\Delta L}{h} = 0.412\frac{(\varepsilon_{reff}+0.3)\left(\frac{W}{h}+0.264\right)}{(\varepsilon_{reff}-0.2.58)\left(\frac{W}{h}+0.8\right)} \qquad (3)$$

Calculate the length of patch (L):

$$L = \frac{c}{2f_r\sqrt{\varepsilon_{reff}}} - 2\Delta L \qquad (4)$$

Where ΔL is the additional length on both side of the patch due to fringing fields

$$L_{eff} = L + 2\Delta L \qquad (5)$$

L_{eff} is the total length of the patch including the length due to of fringing effect. Using the below parameters in above formulas length and width of patch antenna is calculate as L= 48.73 mm and width is 56.09 mm. Inset feed microstrip patch antenna is shown in fig.1

Table 1: Basic parameters of microstrip patch antenna

Parameter	Polycot
Dielectric constant	1.48
Thickness (mm)	3.0
Loss tangent	0.02
Resonant frequency (GHZ)	2.4

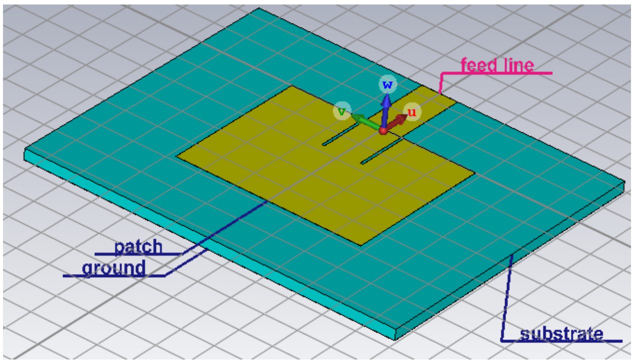

Fig.1 Inset feed microstrip patch antenna

Bandwidth and S-parameter of antenna having a polycot material (combination of curtain cotton and polyester) as a substrate is shown in Fig. 2. A bandwidth of 87.72 MHz and return loss of -27.03 dB is observed for the antenna.

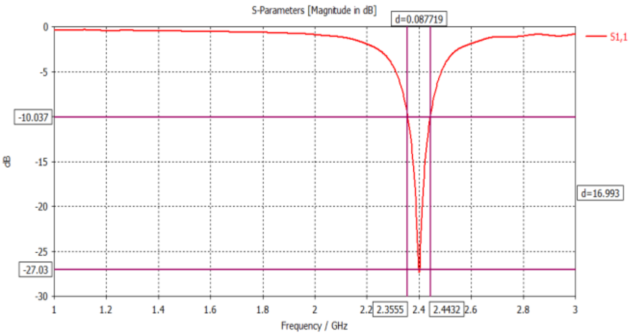

Fig. 2 S-parameter measurement

For polycot substrate, an elevation gain pattern at φ=0 is shown in Fig 3 for 2.4 GHz frequency.

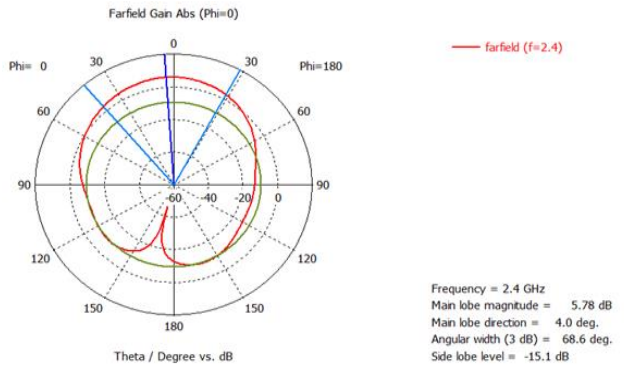

Fig. 3 Elevation farfield gain

A side lobe level has been reduced by 15.1 dB with a 5.78 dB gain in the main lobe direction of 4 degree. An angular beam-width of 68.6 degree is observed at θ= 4 degree.

Effect of body surface on antenna performance:
Wearable antennas have to be worn on a human body. So change in behavior of antenna due to close proximity of lossy body is required to be investigated. In this section performance of antenna on a flat body phantom model is tested. A three layered phantom model at 2.4 GHz frequency is designed [14]. This phantom model assumes different parameter value for different part of the human body, as listed in table 2.

Table 2: Parameters of body phantom model

	Permittivity	Conductivity	Thickness (mm)
Muscle	52.79	1.705	23
Fat	5.28	0.1	8
Skin	31.29	5.0138	2

An antenna with flat body phantom model is shown in Fig.4

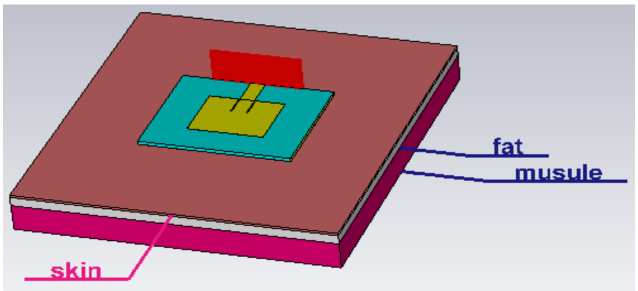

Fig.4 Antenna with flat body surface

Bandwidth and S-parameter of antenna having a polycot material (combination of curtain cotton and polyester) as a substrate on flat body phantom is shown in Fig.5. A bandwidth of 103.74 MHz and return loss of -29.35 dB is observed for the antenna.

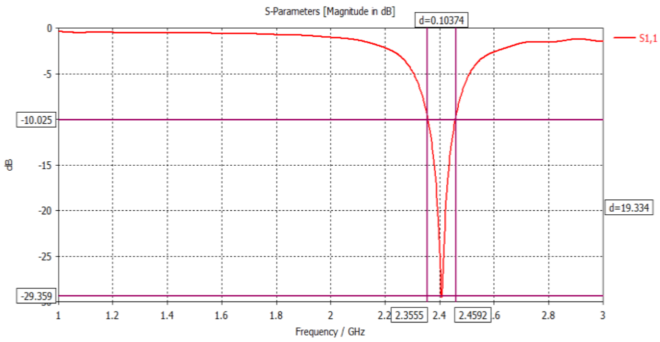

Fig. 5 S-parameter measurement on flat body phantom

An elevation gain pattern for polycot cotton at φ=0 degree is shown in Fig 3.12(a) for 2.4 GHz frequency.

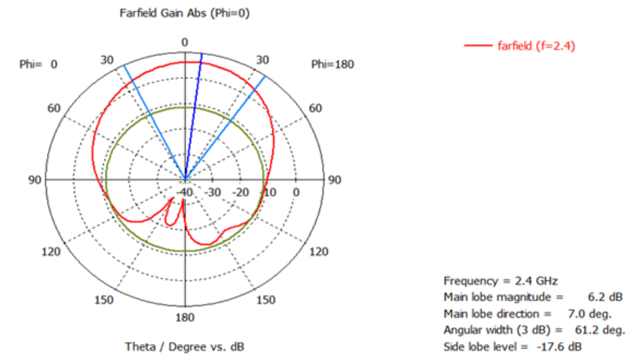

Fig. 6 Elevation farfield gain on flat body phantom

A side lobe level has been reduced by 17.6 dB with a 6.2 dB gain in the main lobe direction of 7 degree. An angular beam-width of 61.2 degree is observed at 7 degree. Azimuth far-field gain at θ=0 is shown in Fig. 3.12 (b)

When a patch antenna is subjected to bend, its effective size/dimensions change leading to a variation in performance parameters. Another effect of bending is an increase in back radiations due to impedance mismatching source and antenna. In the literature, it is found that bend radius of antenna is 76.2 mm when it is worn on human's arm or leg. Antenna on bending body surface is shown in fig. 7.

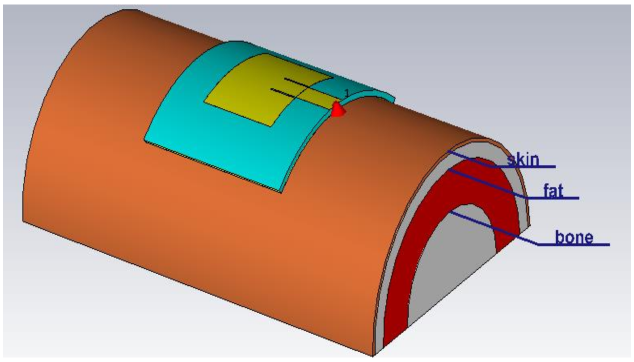

Fig.7 Antenna with bending body surface

The return loss of antenna with polycot substrate is -18.05 dB at the resonant frequency 2.4 GHz, and shown in Fig. 8. The bandwidth of 138.06 MHz could be achieved.

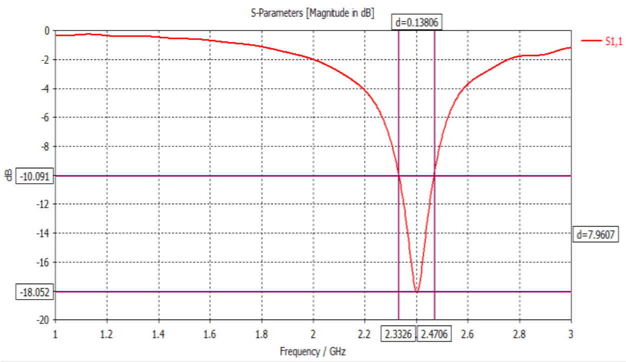

Fig. 8 S-parameter measurement on bending body phantom

Gain patterns for polycot at φ=0 degree is shown in Fig 9. A side lobe level has been reduced by 19.3 dB with a 5.09 dB gain in the main lobe direction of 1 degree. An angular beam-width of 84.6 degree is observed at 1 degree.

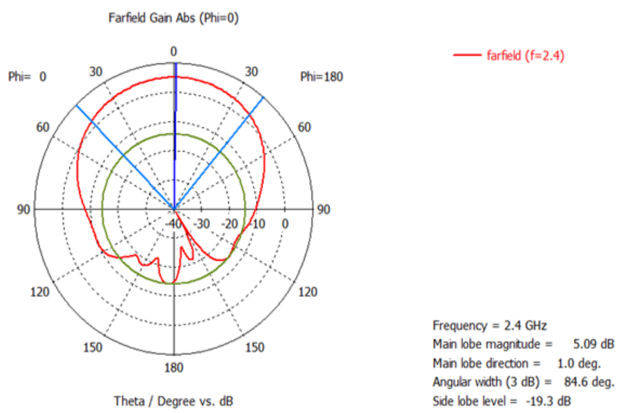

Fig. 9 Elevation farfield gain on bending body phantom

III. RESULT ANALYSIS AND DISCUSSION

A microstrip antenna operating at 204 GHz is designed using polycot substrate which is combination of polyester and cotton. The simulated results are analyzed on the basis of performance parameters return loss, bandwidth and gain for the flat surface without body phantom and with body phantom. Further antenna has been analyzed in bending condition also. The simulated results are shown in table 3.

Table 3: Return loss, bandwidth and gain

	Flat surface	**Flat body surface**	**Bending Body Surface**
Return loss (dB)	-27.03	-29.35	-18.05
Bandwidth	87.72	103.74	138.06
Gain	5.78	6.2	5.09

From the results it is observes that performance parameters have been improved on body phantom, it means it provide the favorable conditions communication. But at the same time gain and return loss has been reduced which can be further improved using metamaterials.

REFERENCES

[1] A. Tronquo, H. Rogier, C. Hertleer, and L. Van Langenhove, "Robust planar textile antenna for wireless body LANs operating in 2.45 GHz ISM band," Electron. Lett., Vol.**42**, pp.**142–143, 2006.**

[2] C. Hertleer, A. Tronquo, H. Rogier, L. Vallozzi, and L. Van Langenhove, "Aperture-coupled patch antenna for integration into wearable textile systems," IEEE Antennas Wireless Propag. Lett., Vol.**6**, pp.**392–395, 2007.**

[3] P. Salonen and Y. Rahimat-Samii, "Textile antennas: effects of antenna bending on input matching and impedance bandwidth," in IEEE Aerospace and Electronic Systems Magazine, Vol.**22**, No.**3**, pp.**10-14, 2007.**

[4] S. Zhu and R. Langley, "Dual-band wearable antennas over EBG substrate," in Electronics Letters, Vol.**43**, No.**3**, pp.**141-142, 2007.**

[5] R. Salvado, C. Loss, R. Gonçalves and P. Pinho, "Textile materials for the design of wearable antennas: A survey", Sensors, 12, pp.**15841–15857, 2012.**

[6] S. Brebels, J. Ryckaert, B. Come, S. Donnay, W. D. Raedt, E. Beyne, and R. P. Mertens, "SOP integration and codesign of antennas," IEEE Trans. Adv. Packag., Vol.**27**, pp.**341–351, 2004.**

[7] C. Hertleer, A. Van Laere, H. Rogier, and L. Van Langenhove, "Influence of relative humidity on textile antenna performance," Textile Res. J., Vol.**80**, No.**2**, pp.**177–183, 2010.**

[8] I. Locher, M. Klemm, T. Kirstein, and G. Tröster, "Design and characterization of purely textile patch antennas," IEEE Trans. Adv. Packag., Vol.**29**, No.**4**, pp.**777–788, 2006.**

[9] Z. Wang, L. Zhang, D. Psychoudakis, J.L. Volakis, "Flexible textile antennas for body-worn communication," 2012 IEEE International Workshop on Antenna Technology (IWAT), pp.**205– 208, 2012.**

[10] A. Tronquo, H. Rogier, C. Hertleer, and L. Van Langenhove, "Applying textile materials for the design of antennas for wireless body area networks," in Proc. 1st European Conference on Antennas and Propagation, pp.**1-5, 2006.**

[11] P. Salonen, Y. Rahmat-Samii, M. Schaffrath, and M. Kivikoski, "Effect of textile materials on wearable antenna performance: A case study of GPS antennas," in Proc. IEEE Antennas Propag. Soc. Int. Symp., Vol.**1**, pp.**459–462, 2004.**

[12] C.A. Balanis, Modern Antenna Handbook 3rd edition. A John Wiley and Sons, Inc., Publications, **2005.**

[13] S. Sankaralingam and B.Gupta, "Development of Textile Antennas for Body Wearable Applications and Investigation of Their Performance under Bent Conditions," PIER B, Vol.**22**, pp.**53-71, 2010.**

[14] U. Ali, S. Ullah, J. Khan et al., "Design and SAR analysis of wearable antenna on various parts of human body, using conventional and artificial ground planes," Journal of Electrical Engineering and Technology, Vol.**12**, No.**1**, pp.**317–328, 2017.**

