Effect of Bending on Performance of Circular Patch UWB Wearable Antenna

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Abstract: This study has been done to investigate the effect of bending on performance parameters of UWB wearable antenna. As wearable antenna is to be worn on human body, it is necessary to study the effect of bending on antenna performance parameters. Radiations generated by wearable antenna will be very close to the human body, specific absorption rate has also been studied for various textile materials as a substrate. Rogers 5880 is used as standard reference material for substrate & all results are compared with the reference. Design have been simulated using HFSS software for the frequency range of 1 to 15GHz i.e. UWB & above.

IndexTerms - Circular patch; UWB; Textile material; Wearable; Bending; Return loss; Bandwidth; SAR.

I. INTRODUCTION

The wearable antenna is to be worn on human body, so study of effect of bending is very important while designing an antenna. Similarly, when we bend dielectric material, it changes substrate permittivity and thickness which further affects the bandwidth as well as the resonant frequency of the antenna.

In wearable antenna applications, as antenna is very close to human body, some heat is generated around the antenna, it gets absorbed by the human tissues which affects human body parts. Hence effect of antenna on human body is necessary to be observed.

Specific Absorption Rate - SAR is the parameter that is used to measure the rate at which energy is absorbed by human tissues. It is a measure of the rate at which energy is absorbed by the human body when exposed to a RF electromagnetic field. [5]. The SAR is defined as the rate at which RF electromagnetic energy is imparted to unit mass of biological body. SAR is usually averaged either over the whole body, or over a small sample volume (typically 1 g or 10 g of tissue). SAR is calculated using the formula given as: $SAR=\sigma E/\rho$
Where, σ = electrical conductivity, E = RMS electric field and ρ = sample density.

The Federal Communication Commission (FCC) have limited the SAR to 1.6 W/kg averaged over 1 g of actual tissue. The limit of temperature increase in head tissues is 1 K. The behavior and memory of the people may also get affected if temperature in the head tissue increases beyond limit.
Since UWB antennas provide a kind of Omni-directional radiation pattern component, special attention must be paid to the Specific Absorption Rate (SAR) in order to avoid harm to human body. [2] For wearable antenna jeans fabric, denim, silk, wash cotton, polyester ,curtain cotton, flannel material could be suitable as a substrate material in the UWB range.

II. DESIGN

Sr. No.	Parameter		Dimensions (mm)
1	Substrate Roger 5880	Length	40
		Width	26
		Thickness	0.787
2	Ground	Length	18
		Width	26
3	Patch	Radius	7.76
4	Feed line	Length	13.2
		Width	2.48
5	Step	Length	5.3
		Width	1.7

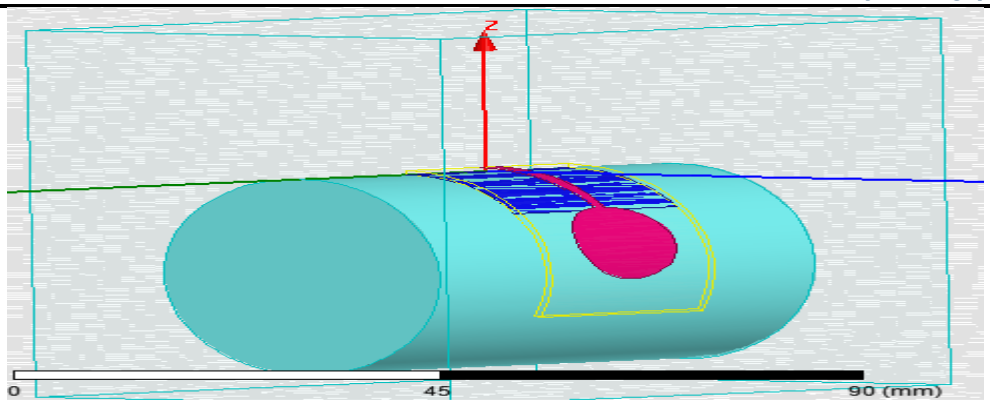

Figure 1 a: Bending of circular patch antenna - Front View

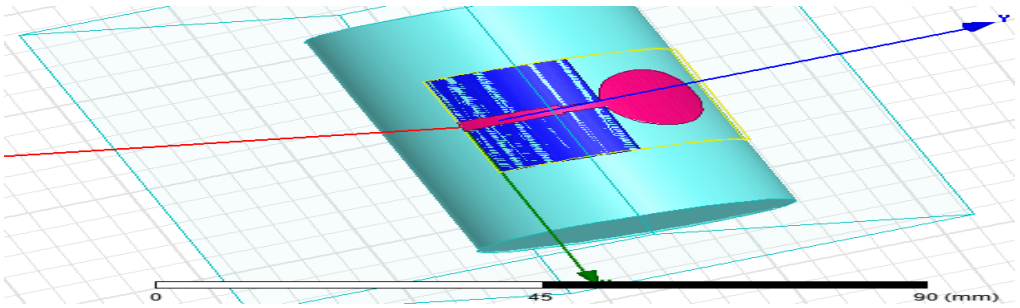

Figure 1b: Bending of circular patch antenna - Top View

III. RESULTS & DISCUSSIONS

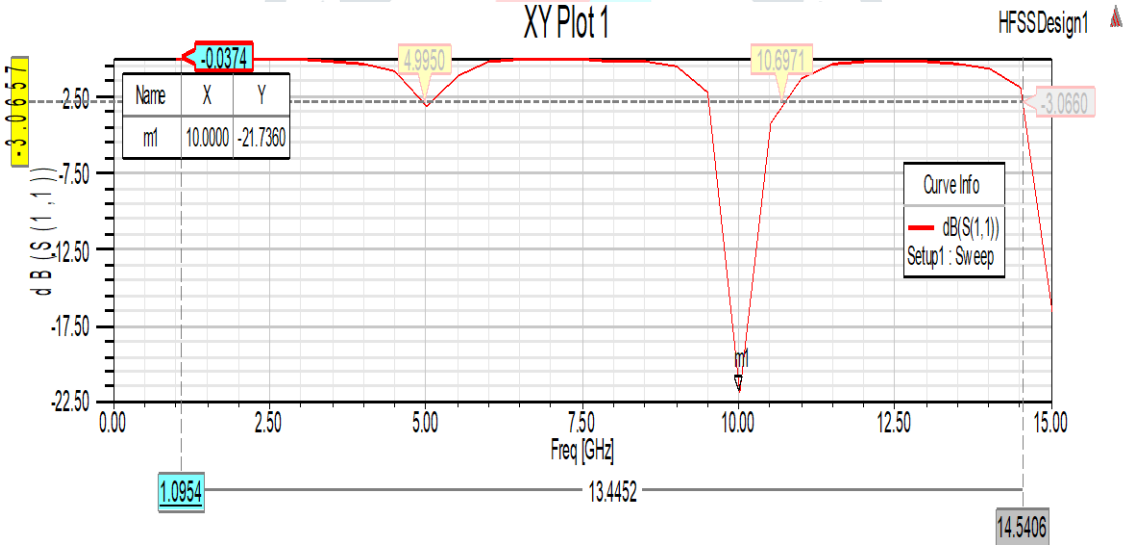

Figure 2: Return Loss (S11(dB) Vs. Frequency(GHz)

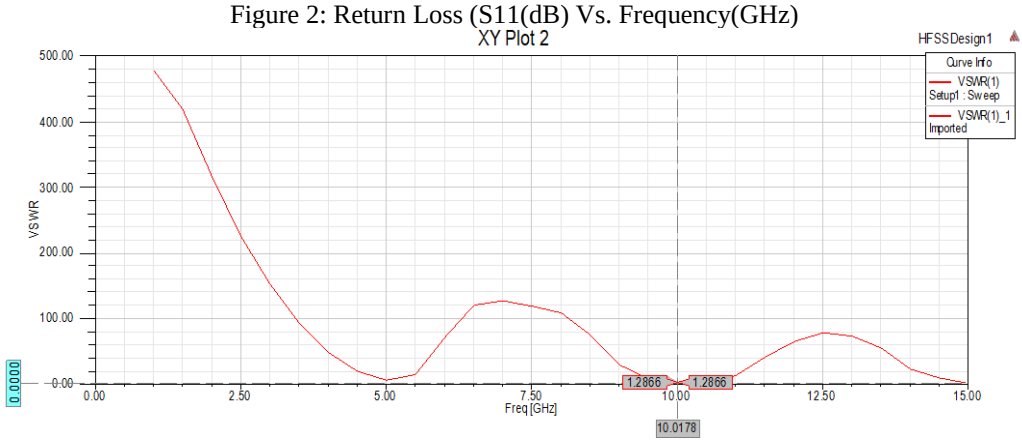

Figure 3: VSWR Vs. Frequency (GHz.)

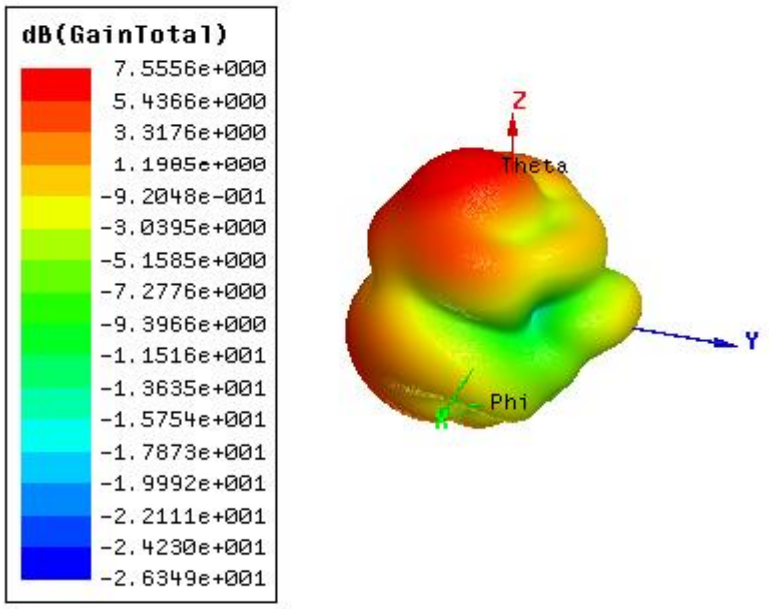

Figure 4: 3D Gain plot

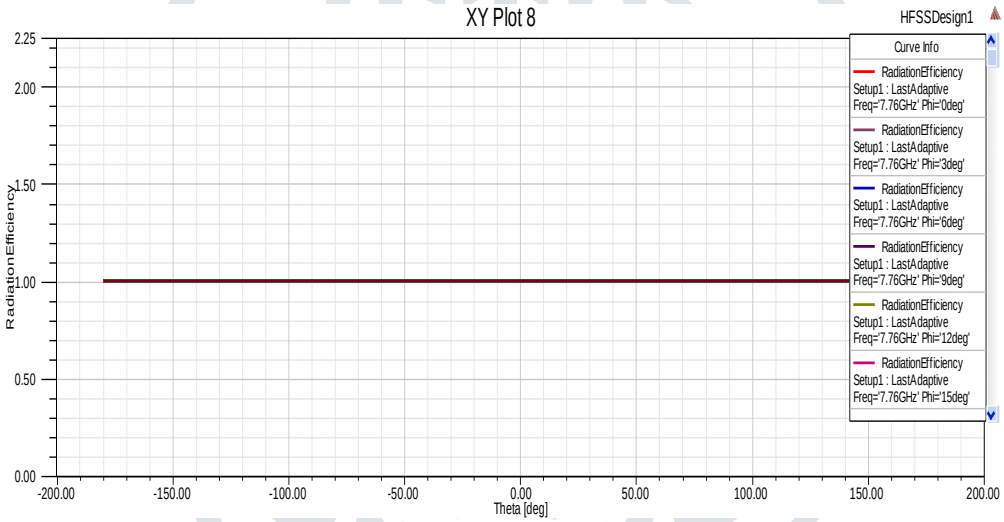

Figure 5: Radiation Efficiency Vs. Frequency(GHz)

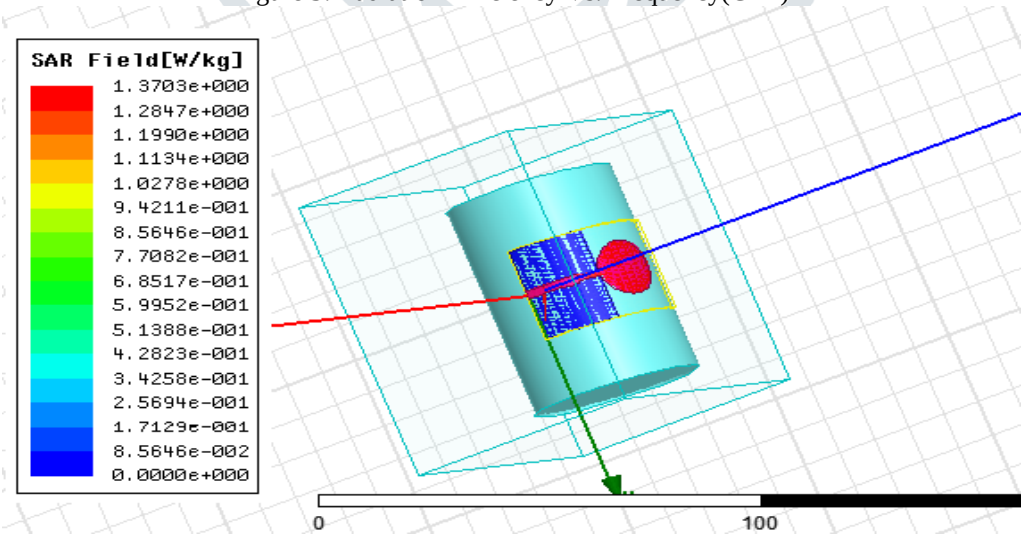

Figure 6: SAR – Specific Absorption Rate for the design with Rogers 5880.

Table 1 Various performance parameters after bending the circular patch antenna.

Sr. No.	Substrate	VSWR	Return LossS11(dB)	Gain (dB)	Bandwidth(GHz)	SAR Field (max.) (W/Kg)
1	Rogers 5880	1.2866@ 10GHz	-21.7360@10GHz	7.55	13.5396	1.3730
2	Polyster	1.4@4.5& 12.5GHz	-16@12.5GHz	6.08	12.2874	1.2781
3	Flannel	1.64411.4. 7GHz	-15.19@11.5GHz	5.98	11.3809	5.260
4	Jeans	1.8@12G Hz	-11.12@12GHz	8.29	11.5739	0.12

Following points have been observed.

1.For the designed circular patch antenna above five parameters have been observed such as VSWR, Return LossS11(dB), Gain (dB), Bandwidth(GHz), SAR Field (max.) (W/Kg). All these parameters have been observed with bending effect. More focus is given on SAR- i.e. specific absorption rate as it is very dangerous for human health.
2.It is observed that VSWR is below 2 for various substrate materials and is lowest for Rogers 5880 as compared with others.
3. Bandwidth is also more for Rogers 5880.Whereas gain for jeans is more. Both accepted power & radiated powers are same by the antenna, so radiation efficiency is 1 i.e. 100%, no power is reflected back to the source.
4. These SAR values are far less than specified standard values as per government rules. All values of SAR field have been calculated over 1gm tissue of human body cell using Ansys HFSS software.

IV. CONCLUSIONS:

Bandwidth is more than 10GHz for the design with various substrate materials, so we conclude that due to bending there is no effect on the bandwidth. Hence, antenna performance is not much affected due to bending effect.
If we look at the last column i.e. SAR field, it shows very low value for rogers 5880 &polyester material as a substrate. But if we use jeans as a substrate, it shows very less value for SAR field. Hence, we can conclude that for wearable applications jeans could be a best material for the substrate, which could be used for UWB wearable applications.

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