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DESIGN OF STAIRCASE S SHAPED WEARABLE ANTENNA FOR MEDICAL PERTINENCE

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Abstract—Wearable antenna accomplishes the enhancement in several applications, especially in a medical field. The prime motive of this paper is to design 2.45 GHz operating frequency of novel S-shaped microstrip patch antenna. This proposed patch antenna incorporates Flame Retardant (FR4) as substrate which is glass-reinforced epoxy laminate with 1.6mm thickness and 4.3 relative permittivity. Initially single element was designed and further modified into 1×2 array. This antenna provides better return loss, voltage standing wave ratio (VSWR) with enhanced signal strength. This design and simulation of antenna has been carried out using Computer Simulation Tool (CST) microwave studio suite. The achieved return loss is -22.068 dB at 2.45 GHz, VSWR is 1.17 with various improved parameters.

Keywords— voltage standing wave ratio (VSWR);patch antenna; Wearable antenna; Computer Simulation Tool (CST); return loss;

I. INTRODUCTION

Wearable antennas are typically used in Wireless Body Area Network (WBAN) for real-time health monitoring purposes. There is lot of research has been carried out on on-body antenna for WBAN application, after the allotment of IEEE 802.15.6 standard [1]-[3]. They are very convenient when integrated to clothing. This integration into patient's garment will not hinder the operations being performed. It can be implemented in various applications such as rescue systems, battle field survival, wearable gaming consoles and patient monitoring systems, [4]-[5]. The important signs of the human body such as electrocardiogram (ECG) ,blood pressure, blood glucose, and heart rate can be monitored on regular basis by employing numerous sensors on the human body[6]-[7].The wireless devices performance characteristics depends on the assimilated antenna element, which must be powerful and tiny. Furthermore, these antennas must be highly efficient and provide better radiation characteristics [8]-[10]. In conclusion, the influence of the human body to the antenna has to be considered well[11]. The antenna should have minimal impedance detuning and radiation power distortion. Through the inspiration obtained from structure of slot antenna, horizontally-polarized radiation pattern with constant gain has to be taken into account. There are various literature survey has been carried out on miniaturizing the size of slot antenna for proposed work.[12]-[18].

Omni directional radiation pattern Antennas are designed are more suitable for military application, rather than wearable application[19]. Denim as substrate and Copper as radiating element are used for designing Antenna which undergo bending conditions in both the E and H planes[20].

II. ANTENNA DESIGN METHODOLOGY

The proposed antenna is designed initially with single patch and modified into 1×2 array and then simulated using CST. The micro strip equations are used to determined analytical properties of proposed antenna. The design is accomplished in CST tool. Fig.1 provides the flow chart which shows the step by step process of antenna design. To design this microstrip patch antenna, four essential parameters such as height of the conductor, operating frequency (f_0), height of the dielectric substrate(h) and dielectric constant of the substrate (ε_r) are needed.The width of the patch(W), the length of the patch(L) are other required important parameter .

Transmission Line equations

For Width (W) $W = \frac{c}{2\, f_0 \sqrt{\left(\frac{\varepsilon_r + 1}{2}\right)}}$

For effective dielectric constant:

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left(1 + 12\,\frac{h}{W}\right)^{-1/2}$$

For Fringing length (ΔL):

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

To find the actual length (L):$L = L_{eff} - 2\Delta L$

FLOW DIAGRAM:

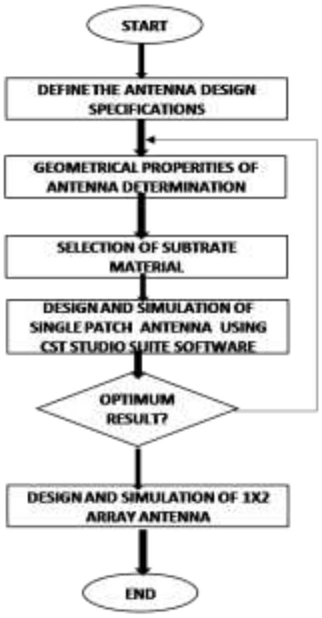

Fig.1.Antenna design flowchart

III. DESIGN OF PROPOSED ANTENNA

At 2.45 GHz operating frequency of microstrip patch antenna has been proposed for wearable application, FR4 substrate used which has 4.3 dielectric constant and 1.6 mm thickness . It is fed by 50 Ω input impedance. The port utilized here is lumped port. The dimensions of the antenna are solely responsible for the decisive results. Table I shows the calculated parameters of the proposed antenna design.

Table I: Design Parameters

PARAMETERS	SYMBOL	VALUE
Operating Frequency	f_0	2.45 GHz

Patch Antenna Width	W	32.75mm
Patch Antenna length	L	32.75mm
Patch Thickness	H	0.035mm
Patch Truncated Corner Fillet Radius	R	20mm
Patch Inner Slits	S	0.5 mmx8mm
Substrate Dimension Along x	Wx	70mm
Substrate Dimension Along y	Wy	65mm
Dielectric constant of substrate thickness	H	1.6 mm
Relative Permittivity	ε_0	4.3

Table I is for designing a single patch. For 1×2 array the substrate is considered as 140 mm × 80 mm. The 1×2 array antenna includes single lumped port.

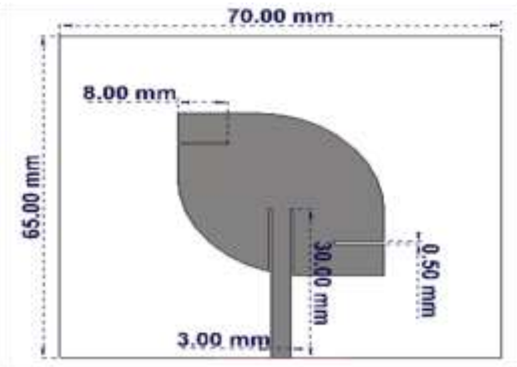

FIG.2.SINGLE PATCH DIMENSIONS

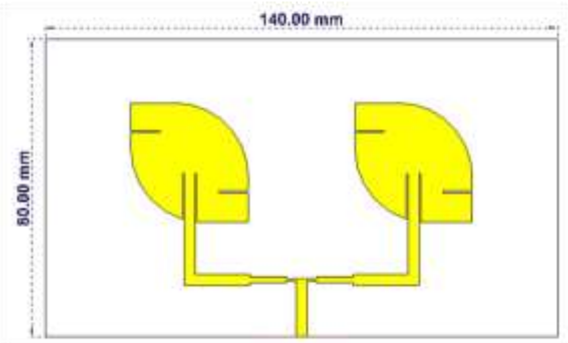

FIG3. 1x2 Array Dimensions

IV. SIMULATION OUTPUT

The simulations are carried out using Computer simulation tool(CST)Microwave Studio Suite and antenna characteristics were analyzed. Fig.4. describes the CST model of the suggested antenna.

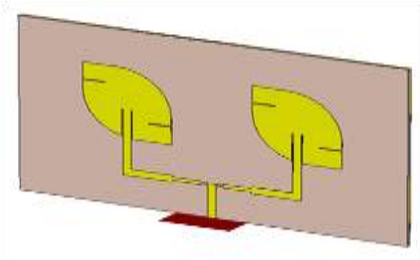

Fig.4.CST Model

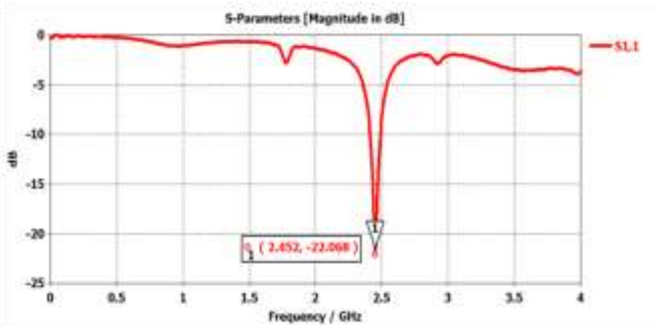

Fig.5.S Parameter:1x2 Array

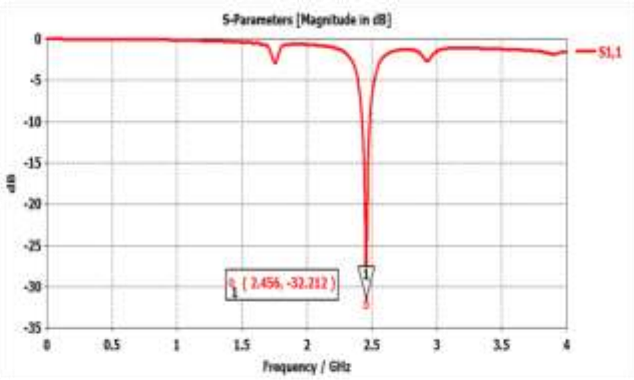

Fig.6.S Parameter: Single Patch

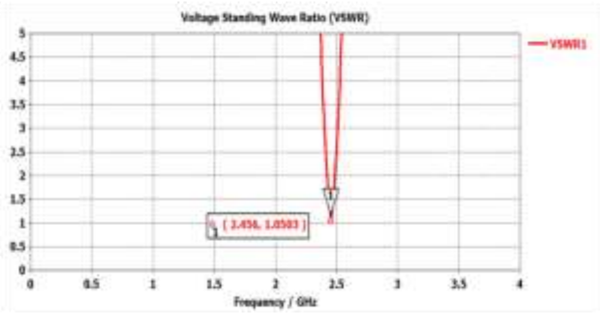

Fig.7.VSWR:Single Patch

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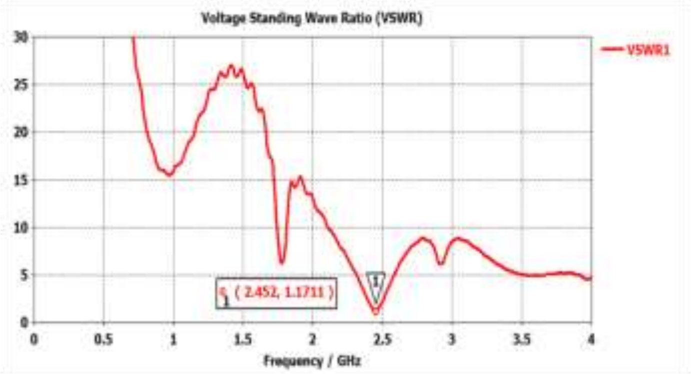

Fig.8.VSWR:1x2 Array

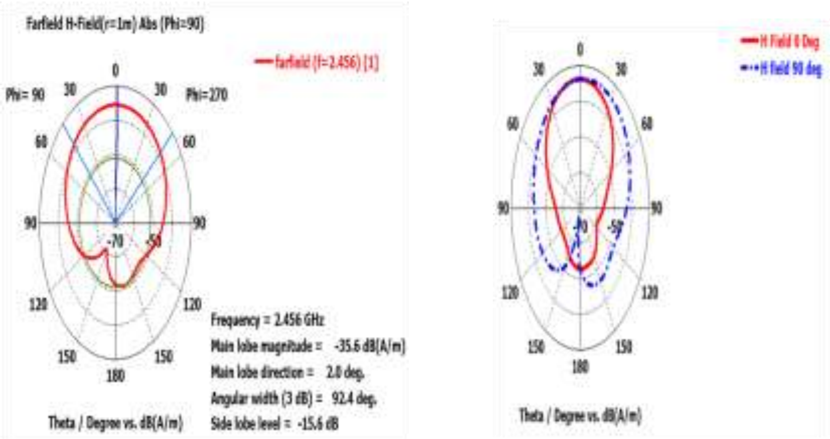

Fig.9.Gain:Single Patch

farfield (f=2.456) [1]

Type	Farfield
Approximation	enabled (kR >> 1)
Component	Abs
Output	Gain
Frequency	2.456 GHz
Rad. Effic.	-5.445 dB
Tot. Effic.	-5.447 dB
Gain	1.185 dBi

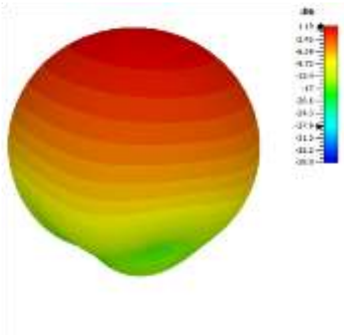

Fig.10.Gain:1x2 Array

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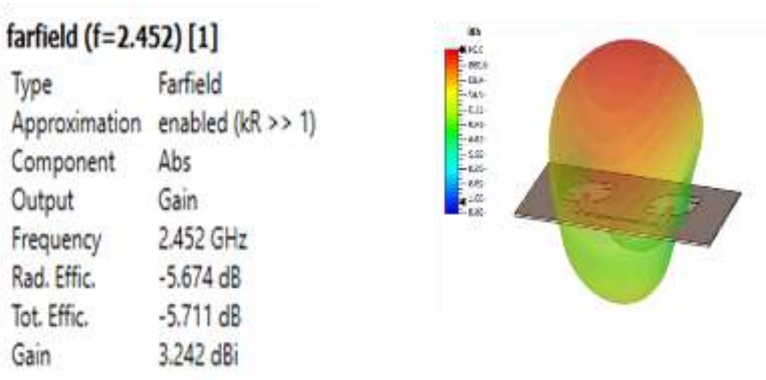

Fig.11.Directivity:Single Patch

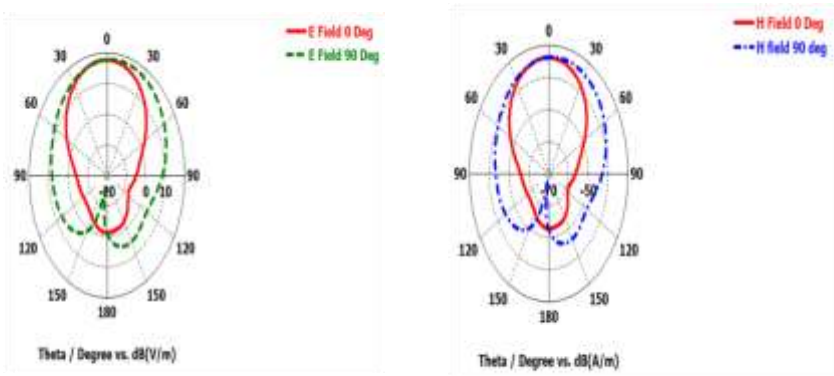

Fig.12.Directivity:1x2 Array

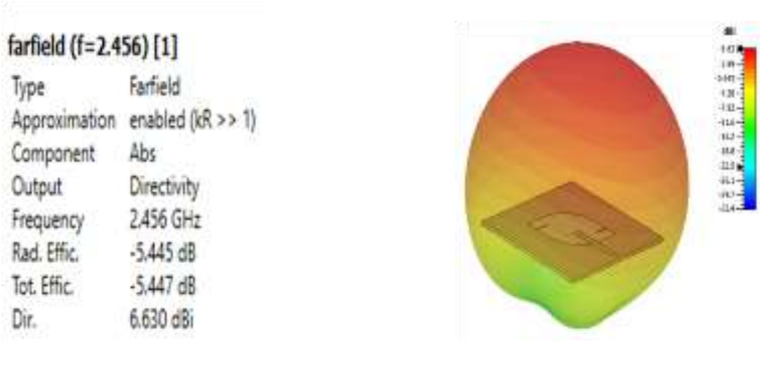

Fig.13.Fields:Single Patch

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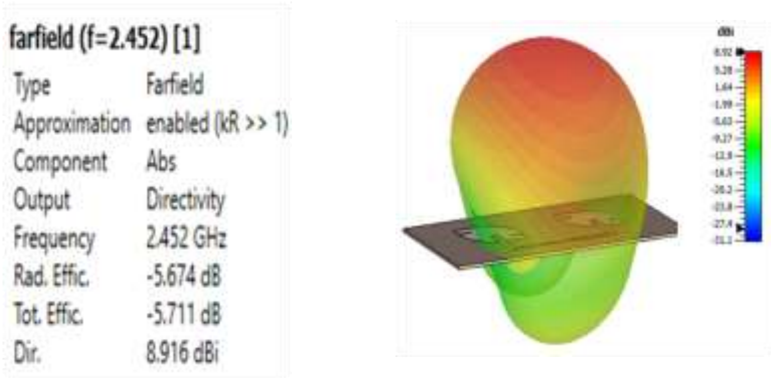

Fig.14.Fields:1x2 Array

V. RESULTS AND DISCUSSION

The simulation output shows that there is great improvement from single element to 1×2 element design. Our prime concern is to improve bandwidth, radiation characteristics, VSWR, efficiency and to increase gain. And this is being achieved and produced in the below result summary (table II).

Table II: RESULT SUMMARY

PARAM ETERS	SIN GLE ELEMENT	1X 2 ELEMENT
Frequenc y	2.45 GHz	2.4 5 GHz
Return Loss	-32 dB	-22 dB
VSWR	1.05	1.1 7
Bandwid th	60 MHz	77 MHz
Gain	1.19 dBi	3.2 4 dBi
Directivi ty	6.63 dBi	8.9 2 dBi

VI. CONCLUSION AND FUTURE WORK

Wearable novel S shaped antenna is designed using CST and presented in this paper. The expected improvements were accomplished through this design. The further work could be carried out to enhance the performance of antenna and size miniaturization.SAR limit provided by the IEEE standard should be verified. The wearable antenna plays a vital role in WBAN application and real time health monitoring.

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