Intention of Novel Metamaterial Based Flexible Patch Antenna for MRI Application

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Abstract- In present day periods, right here has stayed an explicit development withinside the assimilation of collective radio twine to bendable, weave and biomedical introductions.. The projected exertion presents the aim of a twist wearable square reception apparatus utilizing a metamaterial for improved show. There are around reception apparatus use includes bended radio wire, for example, wearable receiving wire, yet the substrate noble cause will have a few defects subsequent to turning and wrinkling after a timeframe. Thus, these examination aims to achieve the deficiency of the fix receiving wire to be fixed in persuading position. The projected setup has been produced metamaterial with bendable at given recurrence range (1-7 GHz). The reception equipment is organized withinside the Computer Simulation Technology (CST) Software and the projected radio cord is then form in a comparable CST. The few limitations, for example, reflection coefficient boundary, VSWR, E-field and H-Field of the various conditions. The recreated results appearance that the assessment execution of the meta-material fix reception apparatus and bendable radio wire.

Indexed Terms- Flexible Antenna, MRI Scanning, Radio frequency Signal, Computer Simulaion,.

I. INTRODUCTION

Magnetic resonance imaging (MRI) is a non-invasive modality with the potential to show comparison among a wide variety of tissues and joint additives along with muscle, cartilage, bone, ligaments, and tendons. Radiofrequency (RF) acquire coils are used to hit upon the localized NMR sign this is finally processed into the MR image. Typically, to decorate the sign-to-noise ratio (SNR), acquire coil arrays are fashioned to embody a generalized shape of the anatomy of interest. Fixed coil arrays are long lasting and designed for unique applications, e.g., mind imaging; however, a couple of sizes are frequently appropriate to facilitate a better in shape and maximize SNR.

Nowadays, Wireless Communication structures are getting more and more more popular. There have been ever-growing demands for Micro strip patch antenna designs that possess the following highly desirable attributes: small size, low cost and easy of fabrication. Wearable and bendy wi-fi structures are gaining great recognition because of their profound ability in a whole lot of important fields. Hence, improvement of bendy and wearable antennas is an essential location that wishes to be addressed for the reason that techniques worried are pretty exceptional from traditional antennas primarily based totally on inflexible substrates.

Additional necessities are enforced with regards to wearable and bendy applications. For example, in body- centric applications, bendy substances need to be biocompatible and compliant with fitness and protection requirements. On the alternative hand, textiles are followed as conductive substances or substrate substances for programs that require apparel integration. For example, in body- centric applications, bendy substances need to be biocompatible and compliant with fitness and protection requirements. On the alternative hand, textiles are followed as conductive substances or substrate substances for programs that require apparel integration.

A. Rectangular Microstrip Patch Antenna

A easy micro strip patch antenna includes a carrying out patch and floor aircraft between them is a dielectric medium called the substrate having a particular value of dielectric constant. The dimensions of a patch are smaller compared to the substrate and ground. Dimensions of a micro strip patch antenna depend upon the resonant frequency and cost of the dielectric constant. Micro strip patch antenna is a dimensional planner antenna configuration having all of the benefits of a printed Circuit board which encompass however aren't restricted to clean to design, clean to fabricate and occasional cost. Though those antenna systems own numerous blessings over different strategies it also has some severe disadvantages which are low bandwidth, low gain, and low efficiency.

B. Patch Antenna

The maximum not unusual place form of micro strip antenna is the patch antenna. Antennas the use of patches as constitutive factors in an array also are possible. A patch antenna is a narrowband, wide-beam antenna fabricated via way of means of etching the antenna detail sample in metallic hint bonded to an insulating dielectric substrate, such as CST, with a non-stop metallic layer bonded to the alternative aspect of the substrate which bureaucracy a floor plane.

C. Microstrip Feed Line

The micro strip feed line is likewise a accomplishing strip, normally of a great deal smaller width in comparison to the patch. The micro strip line feed is easy to fabricate, simple to match by controlling the inset position and rather simple to model. However, as the substrate thickness increases, surface waves and spurious feed radiation increase, which limit the bandwidth for practical designs. But, generally the thickness depends on the type of the substrate used. For ROGER 5880(Lossy) substrate material thickness used is 0.75 mm in common. Figure 1.4 shows the general micro strip feed line configuration

II. EXISTING SYSTEM

The miniaturization of the antenna for wearable biomedical applications, which as rectangular slots in the conventional rectangular patch and bandwidth has been enhanced using hook-shape stub resonator with the ground plane. The antenna is designed on a semi-flexible material of RF/duroid 5880. The design antenna resonated at 2.4 GHz with a 10-dB bandwidth of 1380 MHz. The antenna maintains high gain (2.50 dBi at 2.4 GHz) and efficiency (93% at 2.4 GHz). The permittivity of the flexible substrate will becomes 2.2 and thickness of the antenna 0.0004.the simulation and analyzation of antenna using HFSS for better impedance matching at 2.4 GHz. The antenna resonated at 3.4 GHZ covering a 10-dB bandwidth from 3 GHz to 3.7 GHz with a fractional bandwidth of 20.8%for a conventional partial ground plane. the antenna shows reasonable performance when it is bent along the x-axis and y-axis. Also, SAR1*g* value of the antenna is in the limits (< 1.6 W/kg for an input power of less than 265 mW)

III. PROPOSED SYSTEM

A. Antenna design

- Radiofrequency coils (RF coils) are the "antennae" of the MRI system, broadcasting the RF sign to the affected person and receiving the go back sign.
- To create an adaptable, wearable and stretchable cloth which can make clinical imaging assessments simpler on patients. Imagine going for an imaging consultation and that they strap on a cushty material with the coils embedded inside. Adaptable, wearable and stretchable fabric embroidered with conductive threads that provides excellent signal-to-noise ratio for enhanced MRI scanning.
- The antenna gadgets stayed taken into consideration and reproduced in CST programming. CST is a further reformist rendition of 3-D electromagnetic exam programming for the guarantee of planning, assessing and streamlining the microwave devices and segments. Henceforth, it is easy to use for analysts to manage. Because of its client agreeable limit, the CST programming unquestionably plan and its time space solver is

quick and great. The setup incorporates the substrate 25mm length and 17mm width mined in on the ground plane arranged of copper 0.035mm profundity whose estimation is the comparative as that of the substrate.

B. MRI Design

Magnetic resonance imaging (MRI) is a non-invasive modality with the ability to reveal contrast between a broad range of tissues and joint components including muscle, cartilage, bone, ligaments, and tendons. Radiofrequency (RF) receive coils are used to detect the localized NMR signal that is subsequently processed into the MR image.

Typically, to enhance the signal-to-noise ratio (SNR), receive coil arrays are shaped to encompass a generalized form of the anatomy of interest. Fixed coil arrays are durable and designed for specific applications, e.g., brain imaging; however, multiple sizes are often desirable to facilitate a closer fit and maximize SNR.

IV. BLOCK DIAGRAM

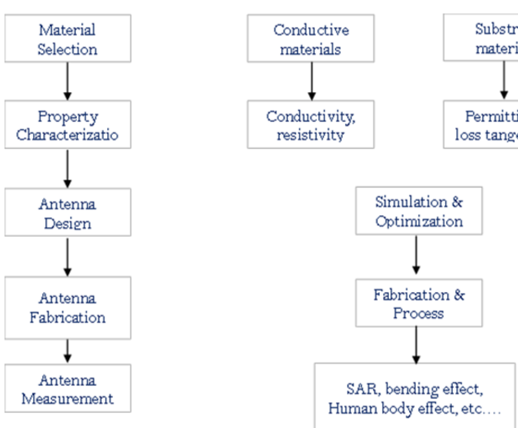

Figure: 1 Design flow procedure

Proposed System Design Specifications

- Roger 5880 material will choose for the proposed system, because of this substrate comfortable with flexible antenna.
- Shape of the proposed system as Meta-surface.
- Proposed Design frequency of 2 GHz – 7 GHz.
- The flexible and wearable coil will plan to implement for a 5T to 7T Magnetic Resonance Imaging System.
- Coil proximity (closeness) to the body can increase the SNR and Image quality.

V. CALCULATION OF PATCH DIMENSION

A. Calculation of the Width (Wp)

The width of the Microstrip patch antenna is given as

$$\mathrm{Wp} = \frac{c_0}{2f_0}\sqrt{\frac{2}{(1+\varepsilon_{rr})}} \qquad (1)$$

where,

c_0 is the free-space velocity of light (i.e). 3×10^8 m/s

ε_r is the dielectric constant of material here 2.2.

B. Calculation of the length (L)

Effective dielectric constant (ε_{reff})

Once W is known, the next step is the calculation of the length which involves several other computations. The first would be the effective dielectric constant. The dielectric constant of the substrate is much greater than the unity. The effective value of ε_{eff} will be closer to the value of the actual dielectric constant εr of the substrate. The effective dielectric constant is also a function of frequency.

The value of the effective dielectric constant is 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 and w are the height and width of substrate material for an antenna respectively.

Effective length (L_{eff})

The effective length of the patch can be calculated as:

$$L_{eff} = \frac{c_0}{2f_0\sqrt{\varepsilon_{reff}}} - 2dL \qquad (3)$$

The dL is the length extension due to the fringing field.

Length Extension (ΔL)

Because of fringing effects, electrically the micro strip antenna looks larger than its actual physical dimensions. For the principle E–plane (x-y plane), where the dimensions of the path along its length have been extended on each by a distance, ΔL, which is a function of the effective dielectric constant and the width-to-height ratio (W/h).

The length extension is:

$$dL = 0.412h \frac{(\varepsilon\varepsilon_{reff}+0.3)(\frac{w}{h}+0.264)}{(\varepsilon_{reff}-0.268)(\frac{w}{h}+0.8)} \quad (4)$$

C. *Calculation of Actual length of Patch (Lp)*

Because of inherent narrow bandwidth of the resonant element, the length is a critical parameter and the above equations are used to obtain an accurate value for the patch length L.

The actual length is obtained by:

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

D. *Calculation of Substrate and Ground Dimensions*

All patch antenna design must have a finite ground plane, with a conducting type of material. The dimensions for the substrate and ground plane would be given in Equations,

Width of the ground is given as: $W_g = W + 6h$

Length of the ground is given as: $L_g = L + 6h$

L is the length of patch antenna

W is the width of patch antenna

h = 0.75mm is the thickness of the substrate

The dimensions for substrate and ground plane has been calculated using CST software.

VI. DESIGN STRUCTURE (SIMULATION DIAGRAM)

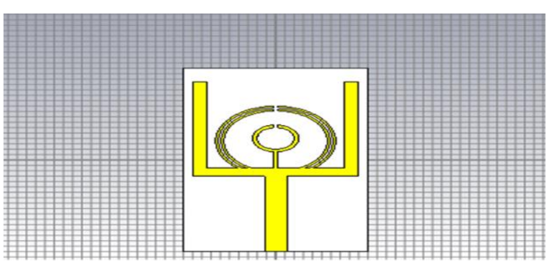

Figure 2: Proposed Antenna without bending

Specifications

Substrate length = 34 mm

Substrate thickness = 0.8

Substrate width = 20 mm

Feed length = 10 mm

Patch length = 30 mm

Inner Ring Radius = 6 mm

Patch width = 18 mm

Outer Ring Radius = 12 mm

Simulation Result

Return loss

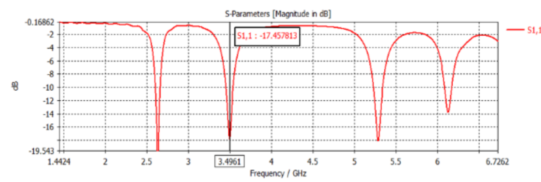

Figure 3: Simulation Return Loss Graph

Measurement Of the reflected wave or single strength travelling return back to a transmitter from an antenna. Without good return loss, an antenna cannot accept your (RF)energy, and therefore cannot have it available to radiate. The Return loss value should above (-10). Here we got return loss value before bending the antenna (-17.45).

Radiation Pattern

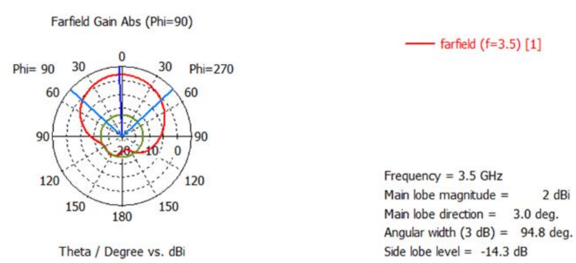

Figure 4: Radiation Pattern Graph

The radiation pattern is defined as a mathematical function or a graphical representation of the far field radiation properties of the antenna, as a function of the direction of departure of the electromagnetic (EM) wave.

VSWR

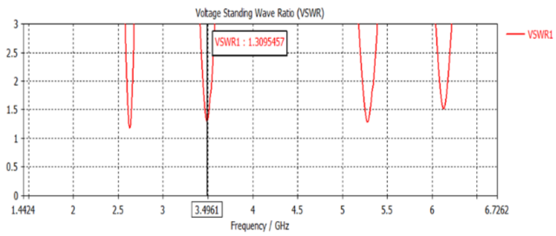

Figure 5: VSWR Graph

A measure of how efficiently radio-frequency power is transmitted from a power source, through a transmission line, into a load . The VSWR value should have less than (2) is ideal. Here we got (1.309) without bending.

VII. ANTENNA STRUCTURE WITH BENDING

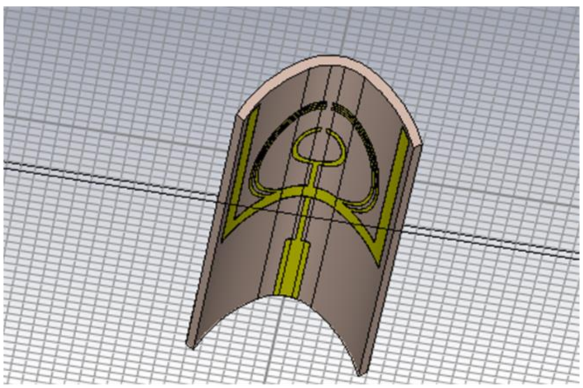

Figure 6: Bending Antenna

Simulation Result

Return loss

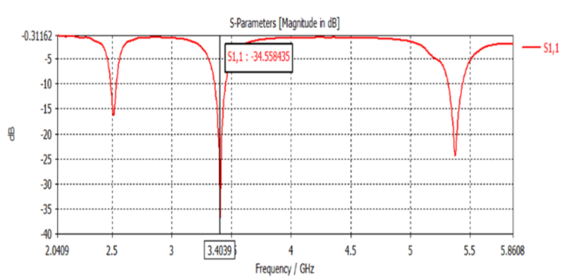

Figure 7: Simulation Return Loss Graph For Bending Antenna

The value of Return Loss after Bending the Antenna, we got (1.04). Now we achieved the ideal value.

VSWR

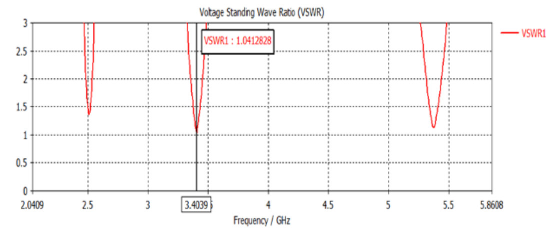

Figure 8: VSWR Graph for Bending Antenna

The value of Voltage Standing Wave Ratio (VSWR) after Bending the Antenna is (-34.55). Here this value is ideal. Already we discussed the value of return loss and VSWR is should be (above -20) and (below 2) respectively. If this condition is achevied. Then we will get a error free signal.

Radiation Pattern

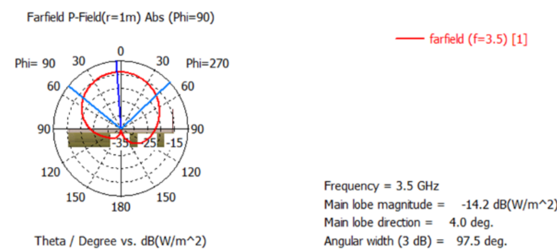

Figure 9: Radiation pattern For Bending Antenna

The radiation intensity is important in antenna design, as it gives the power radiated per unit solid angle. Power flux density - By examining the radiation pattern, it can identify the direction at which the power flux density is maximized and can direct the antenna there.

Table for Comparison of Antenna Performance

Antenna condition	Frequency (GHz)	Return loss (dB)	VSWR	Bandwidth (MHz)
Without Bending	3.4	-17.45	1.309	84
With Bending	3.4	-34.55	1.04	98

Figure 10: comparing the values of with and without bending antenna

VIII. SOFTWARE DESCRIPTION

CST- Computer simulation: CST Studio Suite gives customers access to multiple electromagnetic (EM) simulation solvers which use methods such as the finite element method (FEM) the finite integration technique (FIT), and the transmission line matrix method (TLM). These represent the most powerful general-purpose solvers for high frequency simulation tasks. Additional solvers for specialist high frequency applications such as electrically large or highly resonant structures complement the general-purpose solvers.

CST Studio Suite includes FEM solvers dedicated to static and low frequency applications such as electromechanical devices, transformers or sensors. Alongside these are simulation methods available for charged particle dynamics, electronics, and multi physics problems. The seamless integration of the solvers into one user interface in CST Studio Suite enables the easy selection of the most appropriate simulation method for a given problem class, delivering improved simulation performance and unprecedented simulation reliability through cross-verification.

CONCLUSION

The work is retained on the downside of fix receiving wire shows once the reception apparatus proposition is bended at specific degrees (45) at a given recurrence range (1-7 GHz). The offered of adaptable receiving wire is executed in the Computer Simulation Technology (CST) Software. In this examination, the result shows that the exhibition of the offered reception apparatus is fairly declined, while the receiving wire adaptable is improved, yet the radio wire calm actuates intensely on the resounding recurrence of 3.4GHz. The results of VSWR among the two proposition are inside the ordinary decision after 3 GHz ahead. The receiving wire actually works effectively with bending on the full recurrence at 3.4 GHz in any event, when adaptable. In light of the obtained possibility, the radio wire expectation can be executed as a MRI biomedical application.

REFERENCES

[1] A. Kumar, A. Utsav, and R. K. Badhai, ``A novel copper-tape wideband wearable textile antenna for WBAN applications," in Proc. IEEE Appl. Electromagn. Conf. (AEMC), Dec. 2017, pp. 1_2, doi: 10.1109/AEMC.2017.8325660.

[2] A. Mersani, L. Osman, and J.-M. Ribero, ``Effect of bending on the characteristics of a coplanar textile antenna," in Proc. 18th Medit. Microw. Symp. (MMS), Oct. 2018, pp. 255_257.

[3] and applications,"' IEEE Access, vol. 8, pp. 144778_144808, 2020,

[4] B. Xu, ``A short review of textile applications in antenna design," Trends Textile Eng. Fashion Technol., vol. 1, no. 5, pp. 119_121, Mar. 2018, doi:10.31031/tteft.2018.01.000522.

[5] D. Ferreira, P. Pires, R. Rodrigues, and R. F. S. Caldeirinha, ``Wearable textile antennas: Examining the effect of bending on their performance," IEEE Antennas Propag. Mag., vol. 59, no. 3, pp. 54_59, Jun. 2017.

[6] doi: 10.1109/ACCESS.2020.3013698.

[7] G. Christina, A. Rajeswari, M. Lavanya, J. Keerthana, K. Ilamathi, and V. Manoranjitha, ``Design and development of wearable antennas for tele-medicine applications," in Proc. Int. Conf. Commun. Signal Process. (ICCSP), Apr. 2016, pp. 2033_2037, doi: 10.1109/ICCSP.2016.7754532.

[8] H. Lee, J. Tak, Y. Hong, and J. Choi, ``Design of an all-textile antenna integrated in military beret for GPS/RFID applications," in Proc. Int. Symp. Antennas Propag. (ISAP), 2017, pp. 982_983.

[9] I. Nadeem, M. Alibakhshikenari, F. Babaeian, A. Althuwayb, B. S. Virdee, L. Azpilicueta, S. Khan, I. Huynen, F. Falcone, T. A. Denidni, and E. Limiti, ``A comprehensive survey on `circular polarized antennae for existing and emerging wireless communication technologies," J. Phys. D, Appl. Phys., vol. 55, no. 3, p. 33002, Oct. 2021, doi: 10.1088/1361- 6463/ac2c36.

[10] J. Virkki, Z.Wei, A. Liu, L. Ukkonen, and T. Björninen, ``Wearable passive E-textile UHF RFID tag based on a slotted patch antenna with sewn ground and microchip interconnections,"

Int. J. Antennas Propag., vol. 2017, pp. 27_29, Feb. 2017, doi: 10.1155/2017/3476017.

[11] K. S. Chakradhar, I.V. Rao, D. T. D. Prasad, P. Raju, andV. M. Rao, ``Wearable textile patch antenna for medical applications," Int. J. Innov. Tech- nol. Exploring Eng., vol. 9, no. 2S3, pp. 44_47, 2019, doi: 10.35940/ijitee. b1011.1292s319.

[12] M. Alibakhshikenari, B. S. Virdee, L. Azpilicueta, M. Naser-Moghadasi, M. O. Akinsolu, C. H. See, B. Liu, R. A. Abd-Alhameed, F. Falcone, Huynen, T. A. Denidni, and E. Limiti, ``A comprehensive survey of `metamaterial transmission-line based antennas: Design, challenges,

[13] M. Alibakhshikenari, F. Babaeian, B. S. Virdee, S. Aissa, L. Azpilicueta, C. H. See, A. A. Althuwayb, I. Huynen, R. A. Abd-Alhameed, F. Falcone, and E. Limiti, ``A comprehensive survey on `various decoupling mechanisms with focus on metamaterial and metasurface principles applicable to SAR and MIMO antenna systems,"' IEEE Access, vol. 8, pp. 192965_193004, 2020, doi: 10.1109/ACCESS.2020.3032826.

[14] M. Niswar, M. Nur, A. A. Ilham, and I. Mappangara, ``A low cost wearable medical device for vital signs monitoring in low-resource settings," Int. J. Electr. Comput. Eng., vol. 9, no. 4, pp. 2321_2327, 2019, doi: 10.11591/ijece. v9i4.pp2321-2327.

[15] N. Amaro, C. Mendes, and P. Pinho, ``Bending effects on a textile microstrip antenna," in Proc. IEEE Int. Symp. Antennas Propag. (APSURSI), Jul. 2011, pp. 282_285, doi: 10.1109/APS.2011.5996697.

[16] O. Vermesan and P. Friess, Internet of Things: Converging Technologies for Smart Environments and Integrated Ecosystems. Aalborg, Denmark:River Publishers, 2013.

[17] S. B. Roshni, M. P. Jayakrishnan, P. Mohanan, and K. P. Surendran, ``Design and fabrication of an E-shaped wearable textile antenna on PVBcoated hydrophobic polyester fabric," Smart Mater. Struct., vol. 26, no. 10, 2017, Art. no. 105011, doi: 10.1088/1361-665X/aa7c40.