iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 6 **Issue:** III **Month of publication:** March 2018

DOI: http://doi.org/10.22214/ijraset.2018.3471

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 6 Issue III, March 2018- Available at www.ijraset.com

Design of Circular Loop Antenna using High Impedance Surface (HIS) for Wearable Applications

Ayyisha Fathima M[1], Sathya D[2], Yamuna Yasodha D[3], Thilagam .K[4]
[1, 2, 3] *UG Student, Department of Electronics and Communication Engineering, Velammal Engineering College*
[4] *Associate professor, Department of Electronics and Communication Engineering, Velammal Engineering College* Chennai, India

Abstract: Design of an antenna for wearable application is a challenging task, thus it need to be specially designed to function well on while being worn. In this paper, we present a circular loop antenna mounted over High Impedance Surface (HIS) operating at 2.4 GHz frequency band for wearable application. The designed antenna is simulated using CST Microwave Studio Suite. The antenna is simulated both in free space and four layer model (skin, fat, muscle, bone). It is observed that the VSWR is less than 2 and Specific Absorption Rate (SAR) is below threshold value for Cellular Telephones. The efficiency of the antenna is better on human hand and SAR simulated value is low. S-parameter, gain and SAR of the proposed antenna were calculated.
Keywords: wearable, circular loop antenna, High Impedance Surface, Four layer model, Specific Absorption Rate (SAR).

I. INTRODUCTION

Due to development of Wireless Communication, many portable handsets has been invented. The recent invention is wearable devices such as Smart watch, Google glass, devices for medical application, etc. In medical field wearable devices are used for measuring Blood Pressure, Heart rate, Fitness Tracking, etc. The wearable technology has become boon to the society. At the same time, wearable antenna face increasing challenge in terms of Specific Absorption Rate. Nowadays, Smart Watches are becoming more popular. In recent invention Smart watches [1] act as a wearable computers, which can synchronized with mobile handsets via Bluetooth or Wi-Fi. For this purpose, the designated antenna for transmitting/receiving signals should be small and concealed within the devices. For design of compact and low profile antenna, AMC (Artificial Magnetic Conductor) based antenna are introduced and studied in [2]-[6]. Different types of antenna is used as radiator above the AMC to improve the performance of the antenna. Working principle of AC is Image Theory. According to Image theory, when an antenna is placed over a Perfect Magnetic Conductor (PMC), the images of currents are in the same direction to the antenna current direction which result in constructive Interference. In [2] slot antenna has been designed that operates at 2.45GHz frequency. The efficiency in free space is about 85%, not suitable for wearable application. In [3] monopole antenna is designed and it operates at 2.4-2.48 frequency band. The gain of the antenna is about 4.2 dB and efficiency in free space and human hand model is not given. In [4] PIFA is designed and the gain and efficiency in free space is around 6.3 dB and 50% respectively. In [5] integrated metal frame antenna is designed and it operates at 2.4-2.49 frequency band. The efficiency in free space is about 70% and in one layer model the efficiency drastically reduces to 26%. In [6] slot antenna is designed, the efficiency in phantom hand is about 65%. Phantom hand is made of bone, but the EM waves are absorbed by skin, muscle and fat is not considered. Thus due to these the efficiency decreases rapidly. The author didn't present the efficiency over four layer model. Comparison of antenna for wearable technology is shown in Table 1.

Table I
Comparison of different amc based and wearable type antenna

Ref. No.	Operating Frequency	AMC Based (Yes/No)	Wearable Type (Yes/No)	Gain(Dbi)	Efficiency (%) In Free Sapce	Efficiency (%) Four Layer Model
Proposed work	2.4 GHz	Yes	Yes	4	60	40(four layer model)
[2]	2.45GHz	Yes	No	Not given	85	-
[3]	2.4-2.49 GHz	Yes	No	4.2	Not given	-
[4]	2.4-2.49 GHz	Yes	Yes	Not given	<60	<40
[5]	2.4-2.49 GHz	No	Yes	>3	75	26(one layer)
[6]	2.4-2.49GHz	No	Yes	2.58	75	-

In this paper, we design antenna over Finite size High Impedance Surface (HIS). Use of HIS [7], [10] helps us to design compact and low profile antenna. The antenna is analyzed both in free space and four layer hand model. The SAR value is much lower than the FCC threshold for cellular telephones. The proposed antenna is simulated using CST-MWS suite [12]. The rest of this paper is organized as follows. First, Section II describes the design of our proposed antenna. Then, Section III result and analysis of proposed antenna both in free space and four layer hand model. Finally, conclusion of our proposed antenna in section IV.

II. ANTENNA DESIGN

A. Circular His Design

HIS designed is based on the FR-4 substrate with thickness of 1.6mm ,dielectric constant 4.4 and tangent loss of 0.02. The full ground plane is used at the bottom with the thickness of 0.2mm. The top surface is covered with circular copper rings with period gaps in angular direction. The dimensions of the circular HIS plane is shown in the table 2. The top and bottom view of the HIS plane is shown in Fig.1.

Table 2.
Dimensions of his

Parameter	Dimension
D	22mm
Θ1	84°
Θ2	6°
R	3mm
G1	1mm

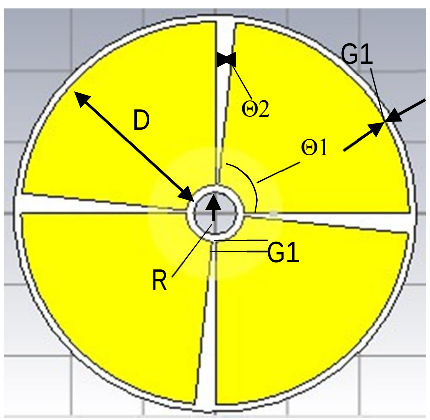


Fig. 1a. Top view of HIS

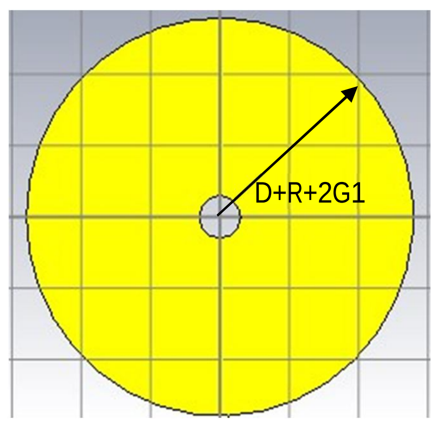


Fig. 1b. Bottom view of HIS

B. Circular Loop Antenna Design

The antenna design is also based on the FR-4 substrate with thickness 1.6mm, dielectric constant 4.4 and loss tangent 0.02. The bottom surface of the antenna is copper free, while the top surface is mounted with loop antenna made of copper with thickness 0.2mm. The dimensions of the loop antenna is shown in table 3. The top view of the antenna is shown in Fig. 2.

III. Table 3.
Dimensions of loop antenna

Parameter	Dimensions
LR1	9mm
LR2	6mm
R	3mm
G1	1mm

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 6 Issue III, March 2018- Available at www.ijraset.com

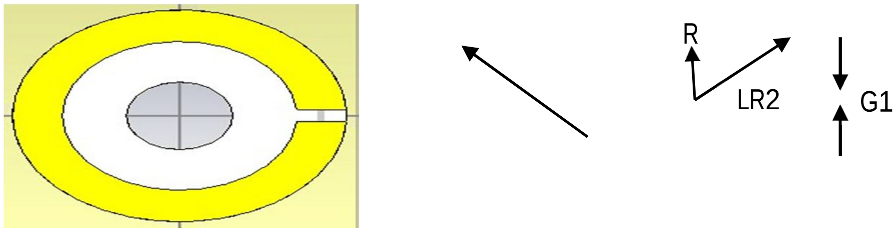
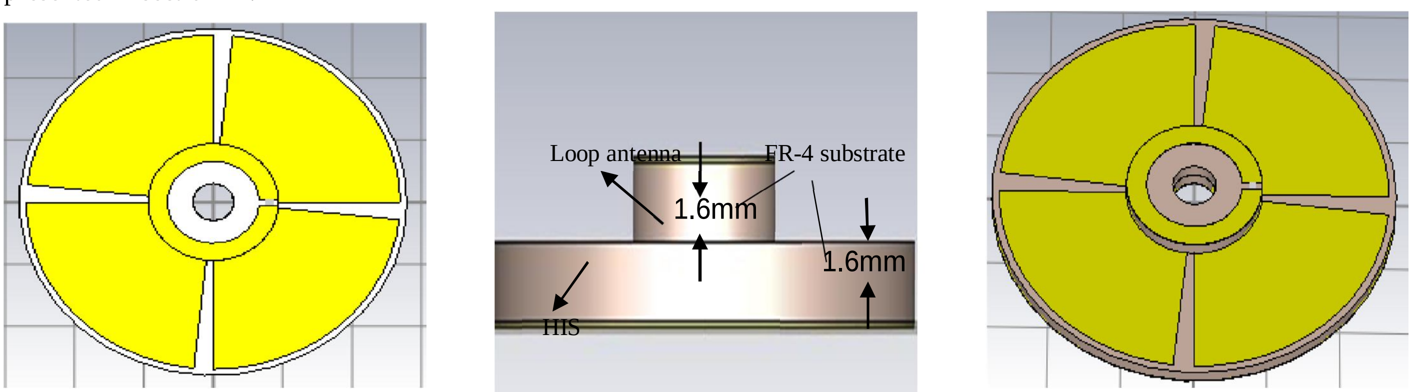


Fig. 2 Top view of circular loop antenna

The configuration of proposed antenna is shown in fig. 3. The antenna is mounted over the High Impedance Surface without any gaps in between shown in fig. 3b. The proposed antenna is simulated using CST-MWS studio suite. The simulated results are presented in section III.



(a) (b) (c)

Fig. 3. Configuration of proposed antenna mounted over High Impedance Surface (HIS) (a) Top view (b) Front view and (c) 3D View of proposed antenna

III. RESULTS AND ANALYSIS OF PROPOSED ANTENNA

A. Antenna in Free Space

The antenna is fed with 50 ohm mini coaxial cable at point A. The proposed antenna is simulated using CST microwave studio and the performance is analyzed in free space. The obtained return loss in free space is shown in Fig. 4. The return loss port 1 is lower than -10dB (lS11l <-10 dB). The VSWR value is less than 2. From the farfield results the directivity of the antenna is 6.39dBi. The efficiency of antenna in free apace is 60%.The gain of the proposed antenna is 4dB.

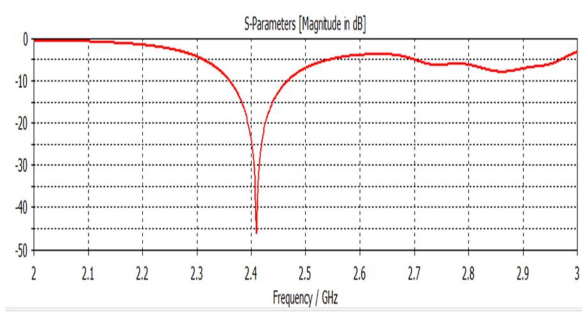


Fig. 4 Return loss of proposed antenna in free space

The return loss of the proposed antenna is less than -45dB. This results in low VSWR. Due to low return loss VSWR value is less than 2.

$$VSWR = (10^{\left[\frac{RL(dB)}{20}\right]} + 1)/(10^{\left[\frac{RL(dB)}{20}\right]} - 1)$$

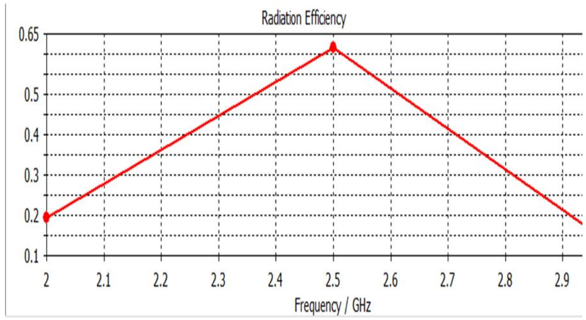


Fig. 5 Efficiency of proposed antenna

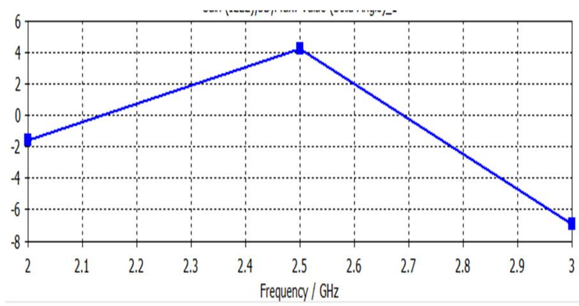


Fig. 6. Gain Vs frequency

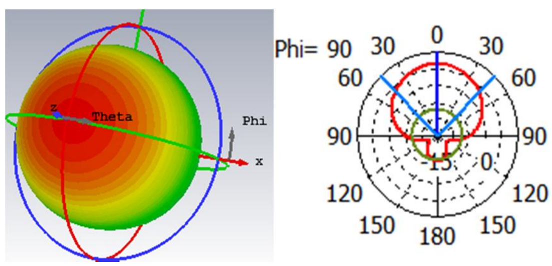


Fig. 7. Farfield results at phi=90 degree 3D and 2D plot of proposed antenna.

B. Antenna over Four Layer Model

The antenna is place over a four layer hand model. The simulation of the impact of the human tissue on antenna performances was performed using a four-layer human tissue model, as illustrated in Fig. 8 The thicknesses of the skin, fat, muscle, and bone are 2, 5, 20, and 15 mm, respectively.

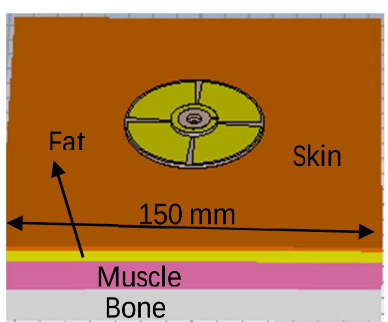


Fig. 8. Antenna over four layer model

The antenna placed above human tissue model at separation of 2mm. The gain is 3 dB and efficiency about 40%. The S-parameter is shown in Fig. 9. The directivity of antenna is 7.13dBi. The Specific Absorption Rate (SAR) is measured. The 1g average SAR is 0.8 which is less than the FCC threshold for cellular telephones.

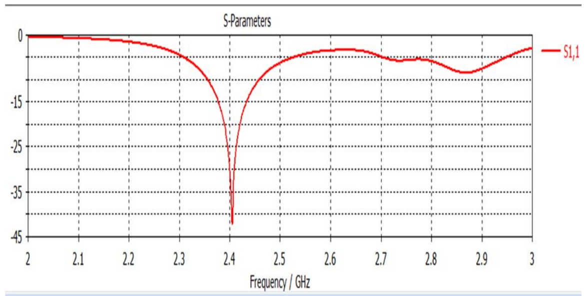


Fig. 9. S-parameter of proposed antenna over four layer model

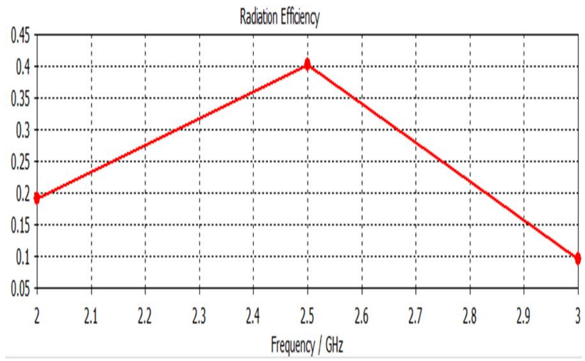


Fig. 10. Efficiency Vs Frequency

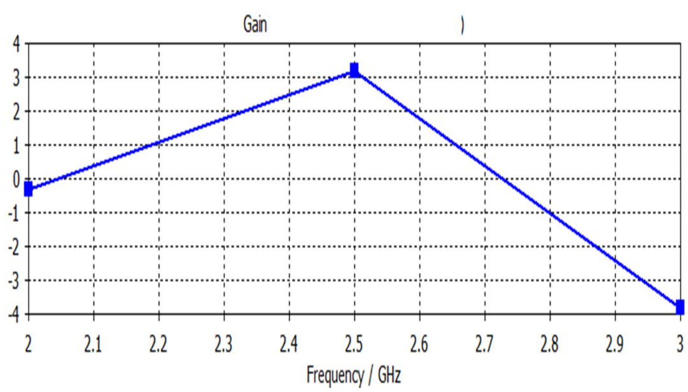


Fig. 11. Gain Vs Frequency

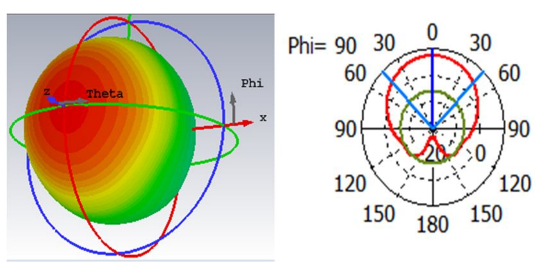


Fig. 12. Farfield results at phi=90 degree 3D and 2D plot.

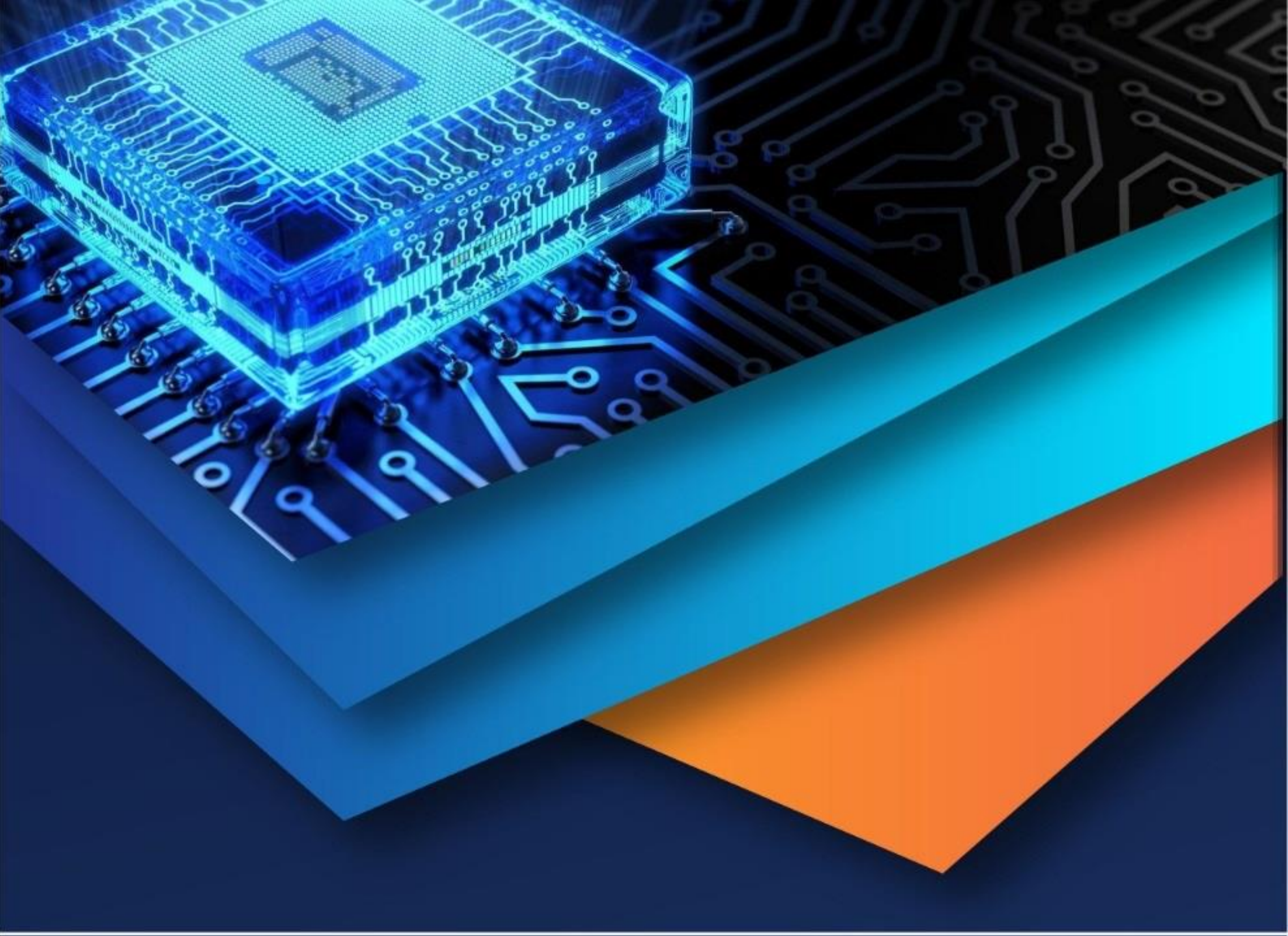
From the above results, we can infer that the performance of antenna is better in both free space and in four layer model. The efficiency of proposed antenna against human tissue is better when compared to other single –input single-output antenna. The design of High Impedance Surface helps us to design compact low profile antenna.

IV. CONCLUSION

A compact and low profile circular loop antenna is designed using High Impedance Surface. The proposed antenna is designed to operate in the frequency band of 2.4GHz. Thus the antenna performance is measured in both free space and human tissue model using CST simulator. The efficiency of the proposed antenna is better against the lossy human tissue and the SAR value is lower than the FCC standard. Further , we planned to implement MIMO technique in future work.

REFERENCES

[1] Smartwatch, Oxford Dictionaries [Online]. Available: http://www.oxforddictionaries.com/definition/english/smartwatch
[2] J. Joubert, J. C. Vardaxoglou, W. G. Whittow, and J. W. Odendaal, "CPW-fed cavity-backed slot radiator loaded with an AMC reflector," IEEE Trans. Antennas Propag., vol. 60, no. 2, pp. 735–742, Feb. 2012
[3] H. R. Raad, A. I. Abbosh, H. M. Al-Rizzo, and D. G. Rucker, "Flexible and compact AMC based antenna for telemedicine applications," IEEE Trans. Antennas Propag., vol. 61, no. 2, pp. 524–531, Feb. 2013.
[4] Y.-S. Chen and T.-Y. Ku, "A low-profile wearable antenna using a miniature high impedance surface for smartwatch applications," IEEE Antennas Wireless Propag. Lett., vol. 15, pp. 1144–1147, 2016.
[5] S. W. Su, and Y. T. Hsieh, "Integrated metal-frame antenna for smartwatch wearable device," IEEE Trans. Antennas Propag., vol. 63, no. 07, pp. 3301-3305, 2015.
[6] Di Wu, S. W. Cheung, Q. L. Li and T. I. Yuk," Slot Antenna for All-Metal Smartwatch Applications," in Antennas and Propagation (EuCAP), 2016 10th European Conference on, pp.1-4, 10-15 April 2016.
[7] M. A. Amiri, C. A. Balanis, and C. R. Birtcher, "Analysis, design, and measurements of circularly symmetric high-impedance surfaces for loop antenna applications," IEEE Trans. Antennas Propag., vol. 64, no. 2, pp. 618–629, Feb. 2016
[8] N. Golmie, N. Chevrollier, O. Rebala, "Bluetooth and WLAN coexistence: challenges and solutions," IEEE Wireless Communications, vol.10, no.6, pp.22-29, Dec. 2003
[9] K. Zhao, Z. N. Ying, and S. L. He, "Antenna designs of smart watch for cellular communications by using metal belt," in Antennas and Propagation (EuCAP), 2015 9th European Conference on, pp.1-5, 13-17 April 2015
[10] J. Sarrazin, A. C. Lepage, and X. Begaud, "Circular high-impedance surfaces characterization," IEEE Antennas Wireless Propag. Lett., vol. 11, pp. 260–263, 2012.
[11] F. R. Hsiao and Y. H. Chiu, "A novel loop antenna design integrated with metal ring for mobile device application," in Proc. Int. Symp. Antennas Propagation, Kaohsiung, Taiwan, 2014, pp. 277-278.
[12] CST MICROWAVE STUDIO (CST MWS), https://www.cst.com/.
[13] Y. Ouyang and W. Chappell, "High Frequency Properties of Electro-Textiles for Wearable Antenna Applications", IEEE Transactions on Antennas and Propagation, vol. 56, no. 2, pp. 381-389, 2008.
[14] H. Li, Y. Tan, B. K. Lau, Z. Ying, and S. He, "Characteristic mode based tradeoff analysis of antenna-chassis interactions for multiple antenna terminals," IEEE Trans. Antennas Propag., vol. 60, pp. 490-502, Feb. 2012.



10.22214/IJRASET

45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Call : 08813907089 (24*7 Support on Whatsapp)