Review Article

BIOMEDICAL Journal of Scientific & Technical Research

ISSN: 2574 -1241

DOI: 10.26717/BJSTR.2024.55.008688

SAR Reduction Method of PIFA Antenna with Metal Frame

Feng Xu*

Information and Communication Engineering, Nanjing University of Aeronautics and Astronautics, China

***Corresponding author:** Feng Xu, Information and Communication Engineering, Nanjing University of Aeronautics and Astronautics, China

ARTICLE INFO

Received: February 15, 2024

Published: March 01, 2024

Citation: Feng Xu. SAR Reduction Method of PIFA Antenna with Metal Frame. Biomed J Sci & Tech Res 55(2)-2024. BJSTR. MS.ID.008688.

ABSTRACT

This paper proposes a low SAR (Specific Absorption Rate) method for PIFA antenna with metal Frame, which includes the following steps:

1. Simulated construction of PIFA antenna.
2. Display frame modifications, the metal frame of display has big influence for SAR.
3. Choose some length of the display.
4. Choose some length of the ground pin.
5. Make simulation to check the simulation list and find out the display frame is 34mm which has the lowest SAR. The length of the display and position and length of the ground pins is critical and sensitive value. The size corresponding to the smaller SAR value is found through parameter scanning. The simulation result shows the redistribution of current leads to the redistribution of the near-field, making the near-field amplitude behind the antenna smaller, thus reducing SAR.

Keywords: SAR; PIFA; Metal Frame

Introduction

The description of SAR, the radiation problem of mobile phone has attracted more and more attention. In order to analyze the influence of electromagnetic radiation on human body more effectively, people put forward the concept of specific absorption rate (SAR) to measure the radiation intensity of electromagnetic wave [1], which is defined as the electromagnetic power absorbed or consumed per unit mass of organism, in W/kg:

$$SAR = d/dt\,(dW/dm) = d/dt\,(dW/\rho dv) \quad \text{......(1)}$$

We normally use the SAR simulation Software, Microwave studio CST as following Figure 1. About the SAR reduction methods of mobile antenna, there is many studies in recent decays, such as in 2003, Minseok lung, Bomson Lee mentioned use EM absorption material to reduce SAR [2,3]. In 2012, Sungtek Kahng; Kyungseok Kahng presented a metamaterial-inspired handset antenna with the SAR reduction [4]. In 2016, M. Haridim presented to Use of Rod Reflflectors to reduce the SAR [5]. In 2021 , Vidya R. Keshwani mentioned textile wearable antenna used in various applications need novel designs to achieve objectives of compact antenna with lowest possible Specific Absorption Rate (SAR).One method used to reduce SAR using EBG structure are briefly described. ISM 5.8 GHz band antenna is designed and modeled in Ansys High Frequency Structure Simulator (HFSS). SAR values with this antenna are computed in human body model. The effectiveness of EBG array structure to reduce SAR to acceptable values is demonstrated by simulations [6,7]. In 2022, Harri Varheenmaa;Pasi Ylä-Oijala presented SAR Reduction with Antenna Cluster Technique [8].

DOI: 10.26717/BJSTR.2024.55.008688

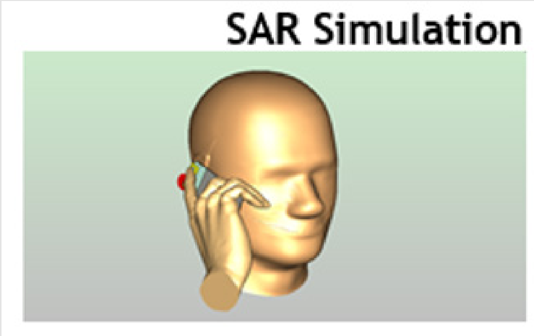

Figure 1: SAR simulation Software, Microwave studio CST.

In this work, A new mobile antenna SAR reduction method mentioned in this paper by Ground metal frame resonator. In theory the display frame decreases SAR values when it is grounded, due to the opposite current phases in PWB and in the display frame. To achieve this, the length and the height of display to proportion to length of the PWB and the wavelength are the critical variables. In this case the purpose was to decrease the SAR values of the lower band. Variables and the characteristics were naturally chosen for lower band. The used head model was simplified to ball, due to the decrease in the simulation time. The diameter of the phantom head was 18cm, including skull with thickness 6mm and inside of skull the "head part". Conductivity, permittivity and values were same than defined on the standard, density value was found from IEEE article.

$$\begin{aligned}&Variables\ \ for\,the\,skull\\&\varepsilon = 17\\&\delta = 0.251\,S\,/\,m\\&\rho = 1850\,Kg\,/\,m^3\\&Variables\ \ for\,the\,head\\&\varepsilon = 42\\&\delta = 0.99\,S\,/\,m\\&\rho = 1050\ \,Kg\,/\,m^3\end{aligned}$$

Simulation Section

Simulated Construction

The structure is simplified version of the real model. If the structure is complicated it can cause problems in the simulation and increase the simulation time. So we use the simulated Structure as Figure 2. The metal parts were modeled as a 0.15mm thick copper. The pins of the antenna are made from the same metal part as the radiator. The frame and chassis has modeled as low loss plastic with a permittivity of 2.5 and loss tangent 0.005. The antenna radiator pattern is close to the pattern. The size of the ground plane is 40mm x 99mmx-0.85mm. The size of the antenna was approximately 36mm x 16mm. Simulated phone structure is Figure 3.

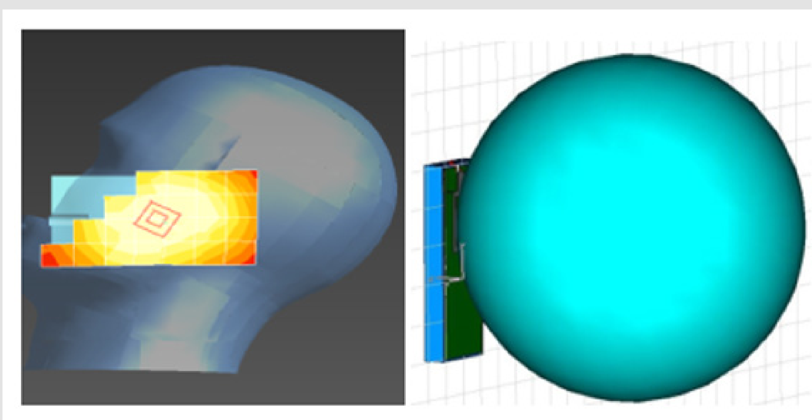

Figure 2: Simulated Structure. Distance between phone and head is 2mm.

 DOI: 10.26717/BJSTR.2024.55.008688

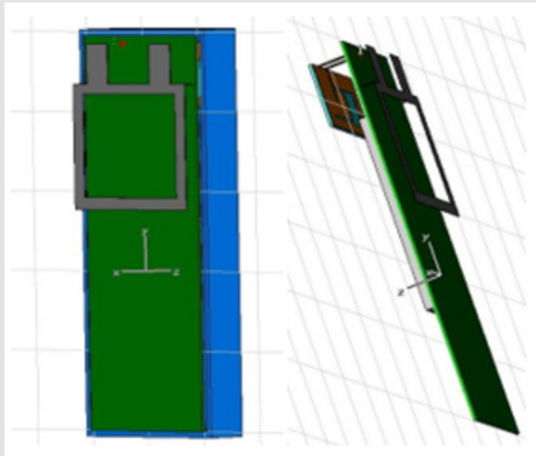

Figure 3: Simulated phone structure.

Display Frame Modifications

In simulation the effect length of the display frame to SAR value was first investigated. Second the position and the length of the ground pins. Third the best results of these two simulations were simulated together. Because of the tight schedule it was impossible to do all the simulation f.e for length of display with 0.5 steps. Simulation was tried to do also by respecting the mechanical issues. The Results, which were found to decrease SAR value remarkably, are also included for additional information. In the initial case the dimensions of the display were the same as presented in Figure 4.

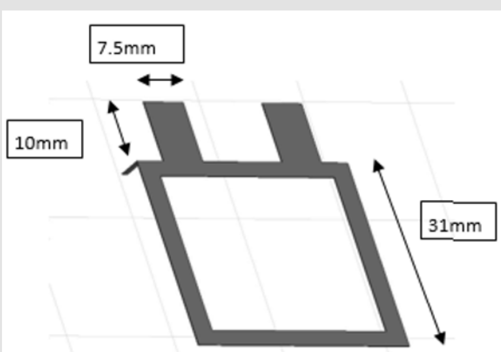

Figure 4: Dimension of the display frame in initial case.

Length of the Display

The length of the display frame was decreased and increased first with 0.5 steps, then with 1mm steps as Figure 5.

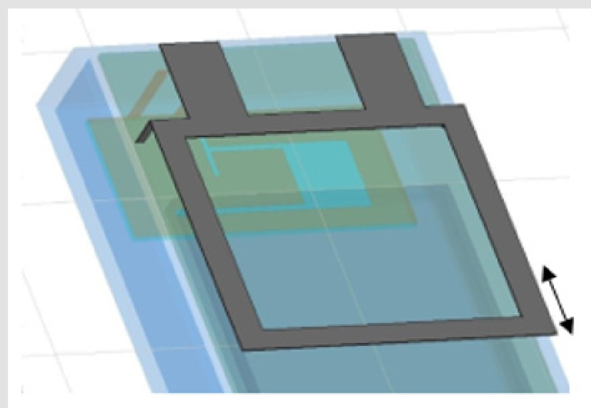

Figure 5: The low corner of the display frame was decreased and increased first with 0.5mm steps then with 1mm.

Length of the Ground Pin

In the second case, as presented in Figures 6-8, only the length of the ground pins was changed. The height of the pin and also height of the display frame was constant. Also, the length of the display was constant, 30.5mm. Length 4.5mm for ground pin was chosen concerning mechanical issues.

DOI: 10.26717/BJSTR.2024.55.008688

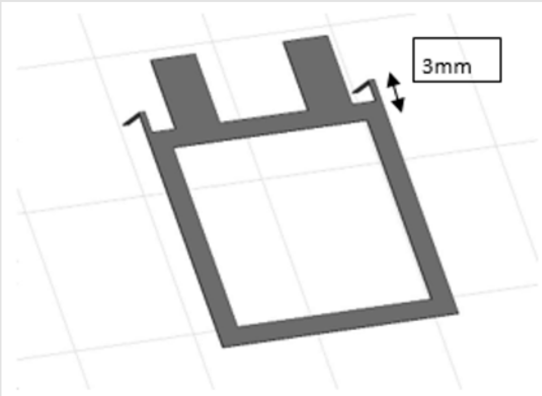

Figure 6: Length of the ground pin 3mm.

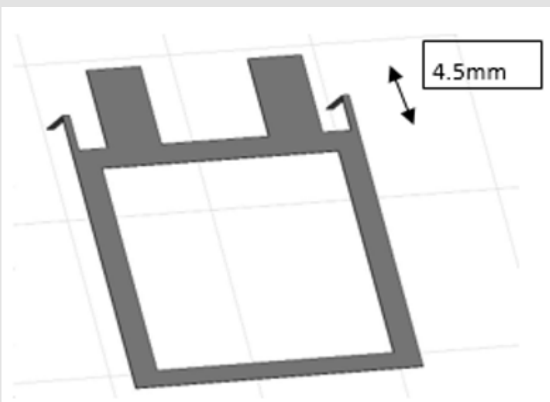

Figure 7: Length of the ground pin4.5mm.

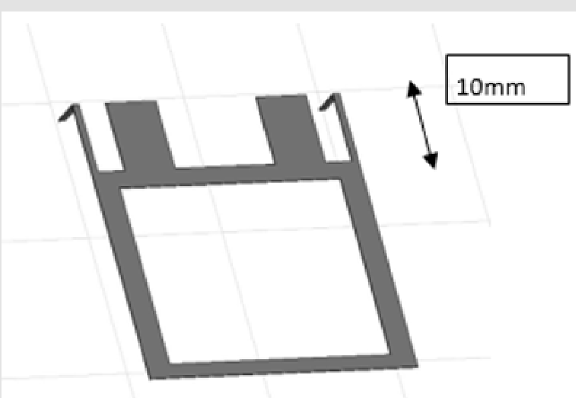

Figure 8: Length of the ground pin 10mmand it is located in the top corner.

Position of the Ground Pin

In the third case, as presented in Figures 9-14, only position of the ground pins was changed. The length of the ground pin was 10mm and length of the display frame 30.5mm. The height of the pin and also height of the display frame was constant.

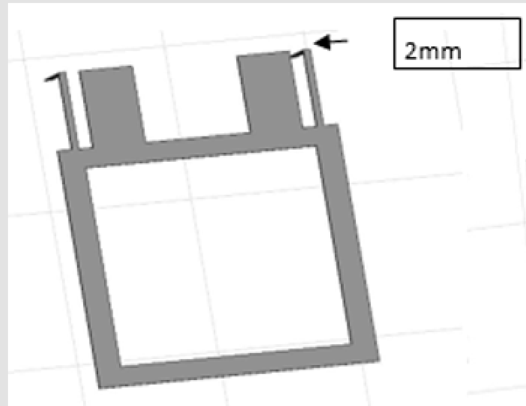

Figure 9: Ground pin moved 2mm.

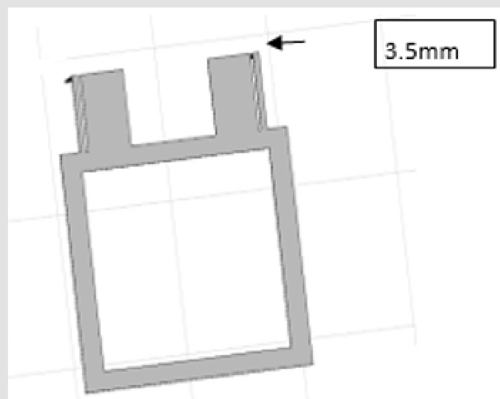

Figure 10: Ground pin moved 3.5mm.

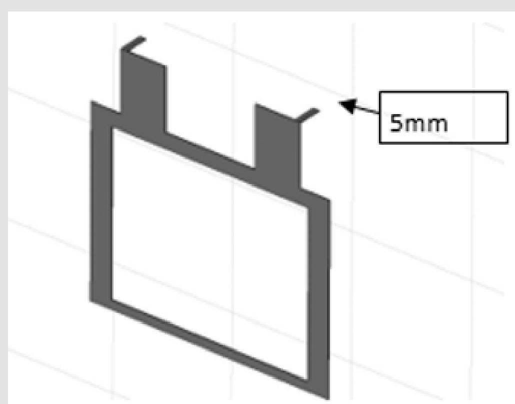

Figure 11: Ground pin moved 5mm.

DOI: 10.26717/BJSTR.2024.55.008688

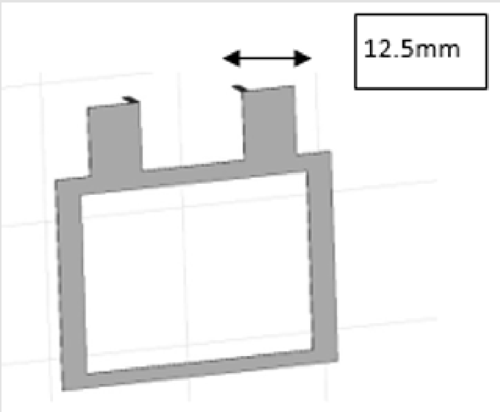

Figure 12. The ground pin moved 7.5mm.

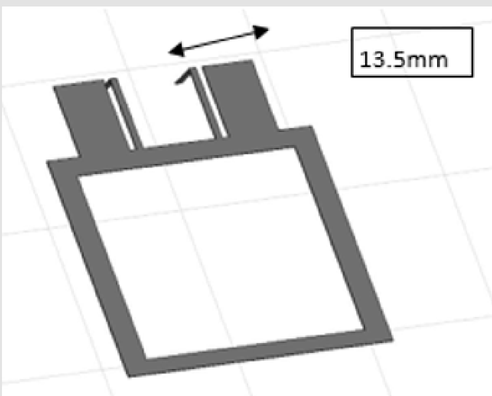

Figure 13: Ground pin moved 13.5mm.

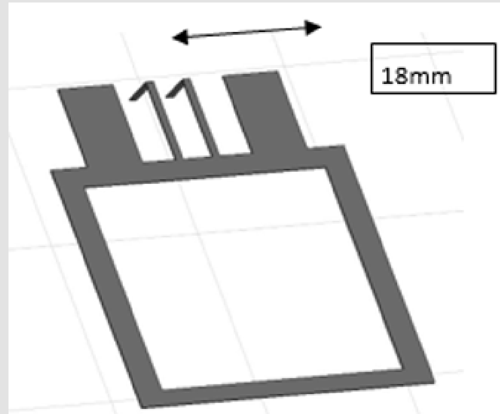

Figure 14: Ground pin moved 18mm.

Simulation Results

Results for the Simulations of Length of the Display Frame in Figures 15-17 [9-11]

Results for the Simulations of Length of the Ground Pin in Figures 18-19

Results for the Simulations of Position of the Ground Pin in Figures 20-21

Simulation Results of the Best Possible Combination in Figures 22-23 [12-14]

In the end, the best possible cases were combined. The simulation was Done by placing 4.5mm long ground pin on the top corner of the 34mm long Display frame. The result was good only 1.96W/Kg, which 1W/kg less than in the beginning.

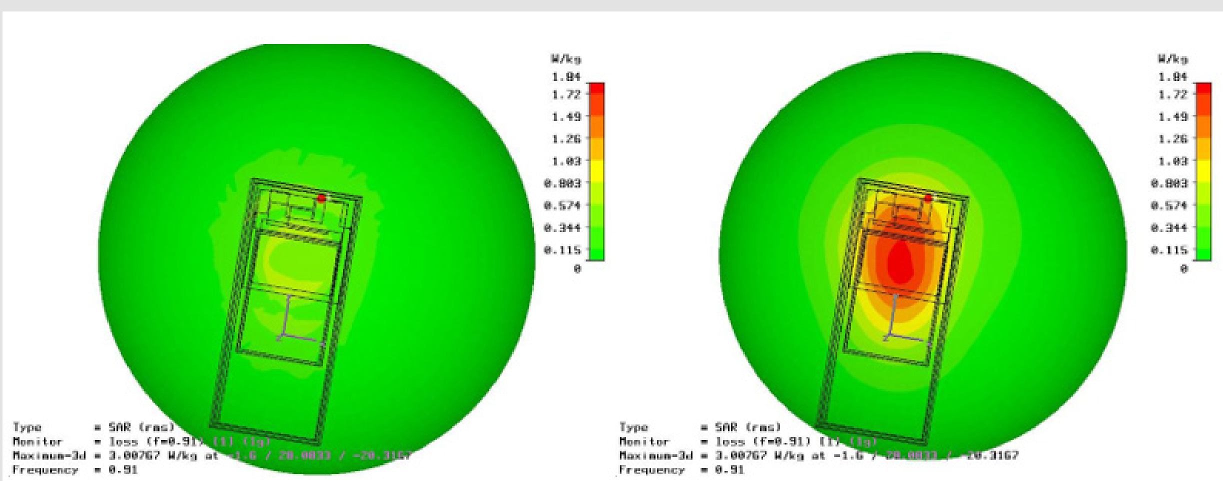

Figure 15: SAR distribution when length of the display frame 31mm. On the left-hand side distribution for the skull on the right hand side for the head [9-11].

 DOI: 10.26717/BJSTR.2024.55.008688

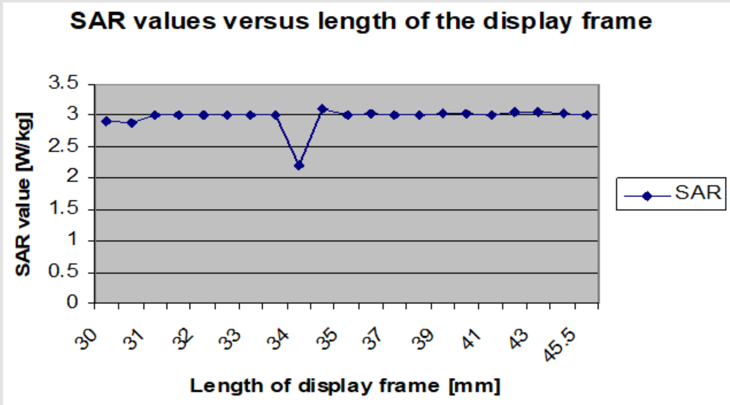

Figure 16: Table for the SAR values versus length of the display frame.

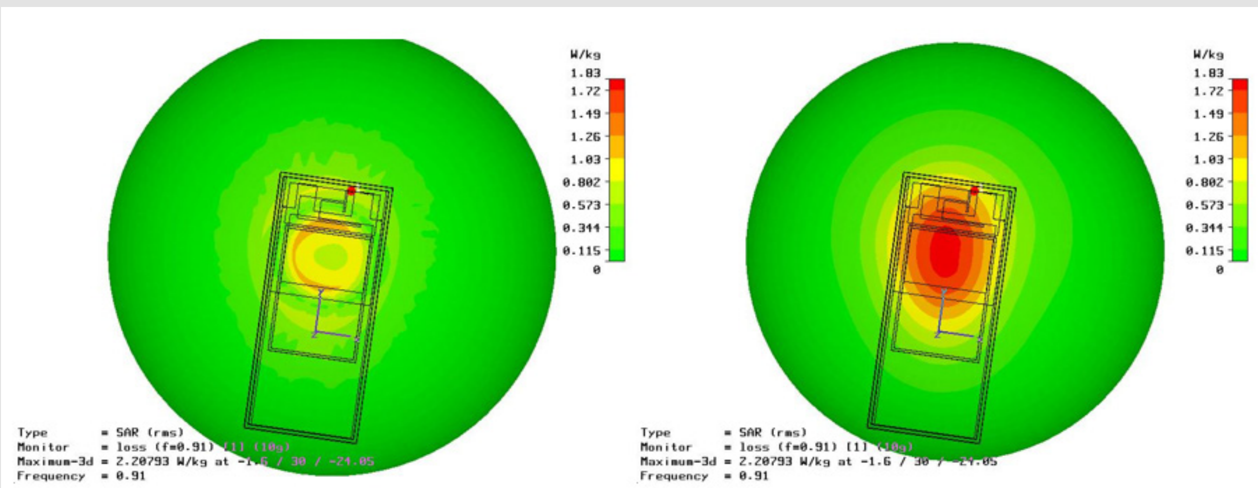

Figure 17: SAR distribution when length of the display frame is 34mm. On the left-hand side distribution for the skull on the right hand side for the head.

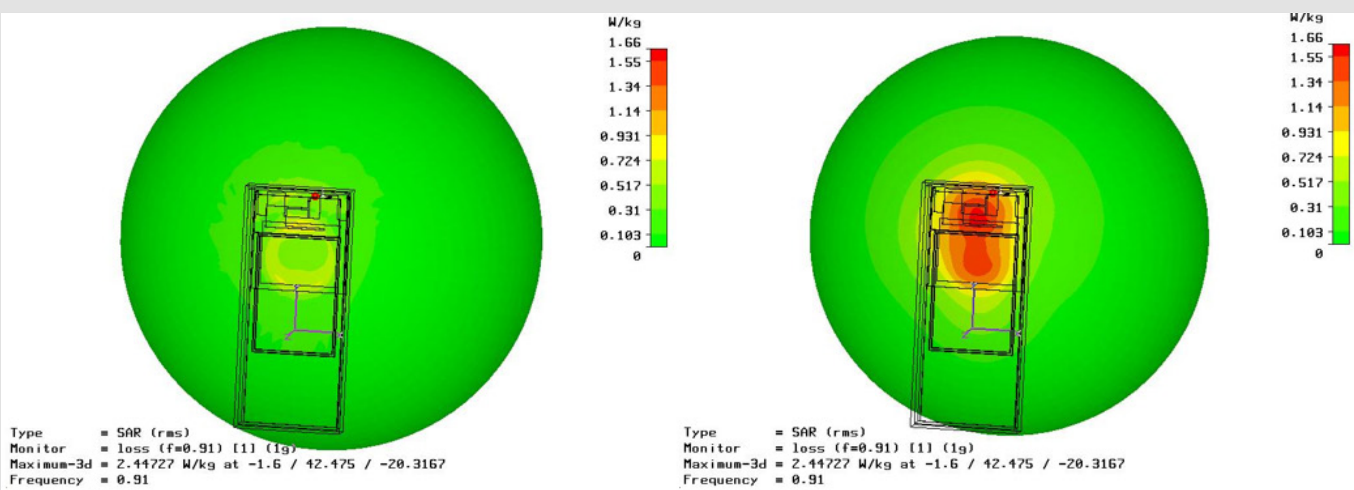

Figure 18: SAR distribution when length of the ground pin was 4. 5mm. On the left hand side distribution for the skull on the right hand side for the head.

DOI: 10.26717/BJSTR.2024.55.008688

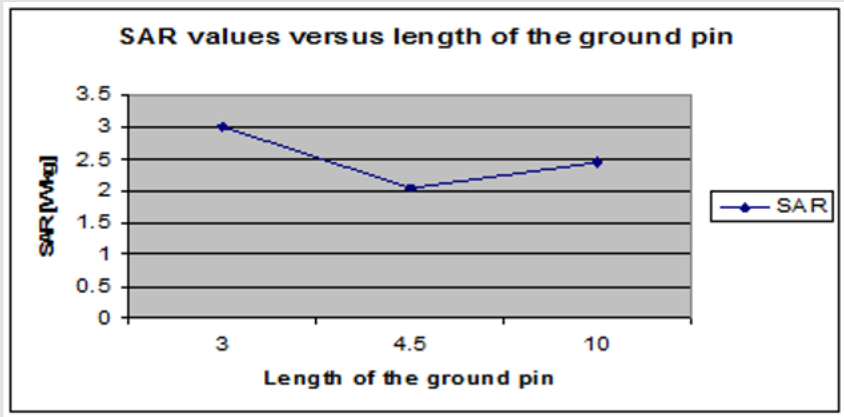

Figure 19: Table for the SAR values versus length of the ground pin. Length of the display frame 30.5mm.

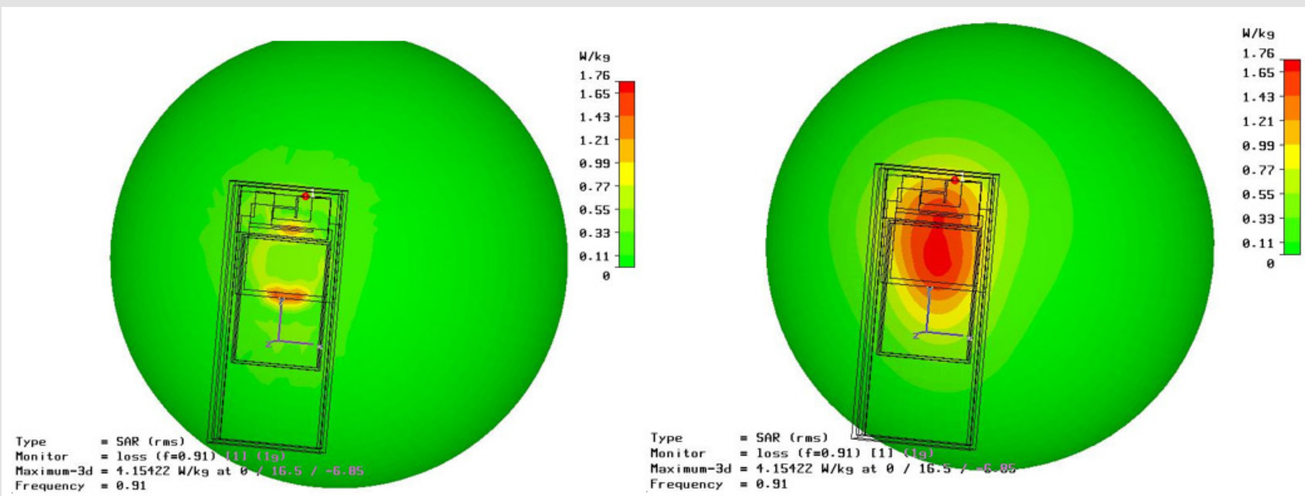

Figure 20: SAR distribution when grounded 12.5 from display frame corner. On the left-hand side distribution for the skull on the right-hand side for the head.

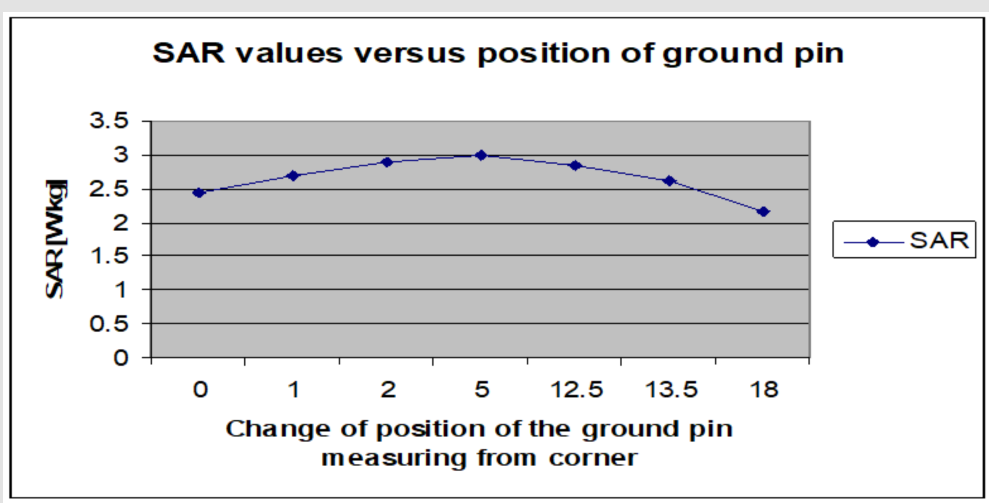

Figure 21: Table for the SAR values versus position of the ground pin.

 DOI: 10.26717/BJSTR.2024.55.008688

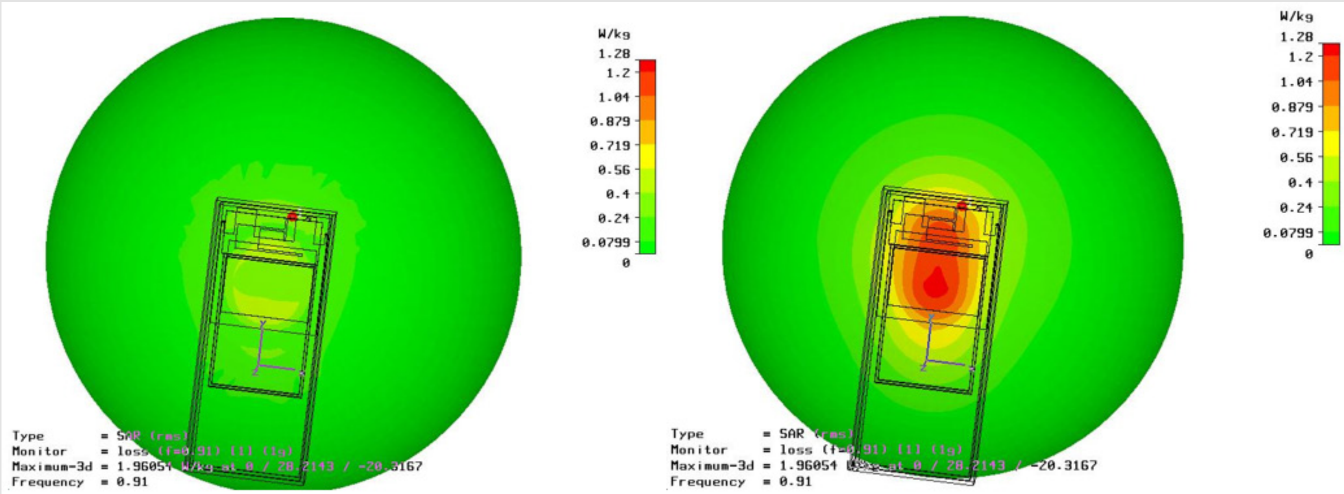

Figure 22: SAR distribution when the length of the display frame was 34mm and ground pins. Pins were placed on the corner. On the left-hand side distribution for the skull on the right-hand side for the head [12-14].

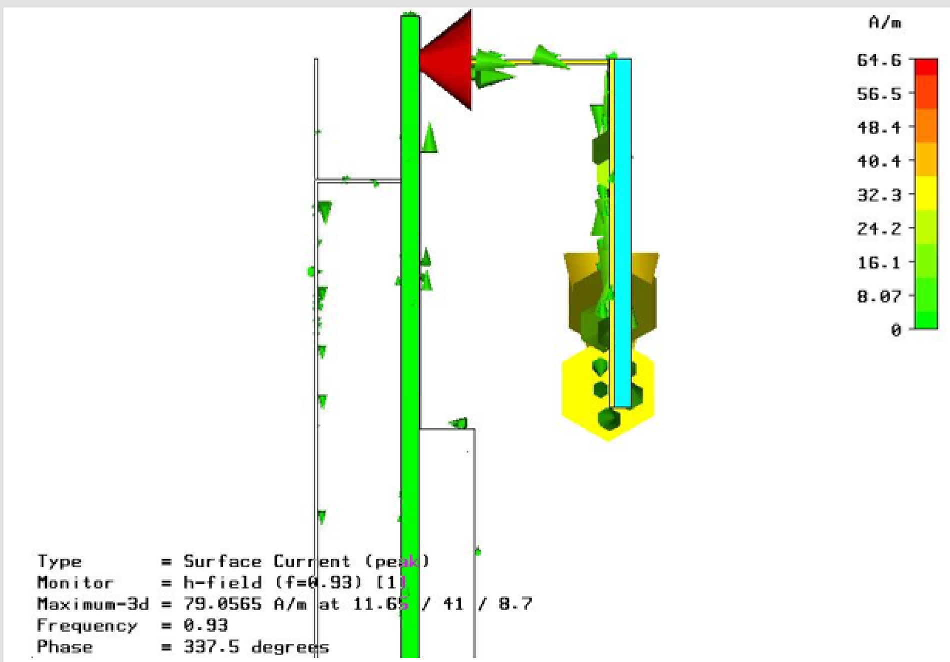

Figure 23: Shows the current flow in the ground plane and in the display frame.

Conclusion

The simulation results show that the length of the display and position and length of the ground pins is critical and sensitive value. Those should be chosen carefully considering the dimensions of the PWB. Lowest SAR value was achieved when length of the display frame was 34mm adding the height of the frame, the total length is 37.85 which is really close to λ /8 wavelength of the GSM. When combining the two best results pins with 4.5 mm length and display frame with 34mm length even lower SAR value was achieved. Correlation between measured and simulated results is expected to be good. In engineering, the size corresponding to the smaller SAR value is found through parameter scanning. It needs to be explained from the physical principle that the redistribution of current leads to the redistribution of the near-field, making the near-field amplitude behind the antenna smaller, thus reducing SAR.

Conflicts of Interest

There are no conflicts to declare.

References

1. Tomoaki Nagaoka, Tetsu Niwa, Soichi Watanabe (2013) Specific absorption rate in human fetus with fetal growth for RF far-field exposure, 2013 Asia-Pacific Microwave Conference Proceedings (APMC).
2. Weiping Dou (2002) Chassis optimisation of monopole antennas for SAR reduction, IEEE Antennas and Propagation Society International Symposium (IEEE Cat. No.02CH37313).
3. Minseok Jung, Bomson Lee (2003) SAR reduction for mobile phones based on analysis of EM absorbing material characteristics, IEEE Antennas and Propagation Society International Symposium. Digest. Held in conjunction with: USNC/CNC/URSI North American Radio Sci. Meeting (Cat. No.03CH37450) 2.
4. Sungtek Kahng, Kyungseok Kahng, Dajeong Eom, Boram Lee, Segyoon Mok (2012) A metamaterial-inspired handset antenna with the SAR reduction, 2012 IEEE International Symposium on Electromagnetic Compatibility.
5. M Haridim (2016) Use of Rod Reflectors for SAR Reduction in Human Head, IEEE Transactions on Electromagnetic Compatibility 58(1).
6. Sebastian Mannaruparampil, Ashita Serrao, Srishti Singh, Freda Carvalho, Ashwini Kotrashetti (2021) Design and Development of Mobile Handset Antenna for Optimum SAR for Mobile Communication System, 2021 IEEE Pune Section International Conference (PuneCon).
7. Vidya R Keshwani, Surendra S Rathod (2021) Assessment of SAR reduction in Wearable Textile Antenna, 2021 International Conference on Communication information and Computing Technology (ICCICT), p. 25-27.
8. Harri Varheenmaa, Pasi Ylä-Oijala, Anu Lehtovuori, Ville Viikari (2022) SAR Reduction with Antenna Cluster Technique IEEE Transactions on Antennas and Propagation 70(12).
9. Amin Khan, Shahid Bashir, Faiz Ullah (2018) Electromagnetic bandgap wearable dipole antenna with low specific absorption rate, 2018 International Conference on Computing, Mathematics and Engineering Technologies (iCoMET).
10. Weibo Liang, Lu-Chu Han, Hongxing Zheng (2021) Research on High Precision Simulation Technology of Specific Absorption Rate of Human Head Model, 2021 International Applied Computational Electromagnetics Society (ACES-China) Symposium.
11. Huda I Hamd, Hind I Mohammed (2018) Comparison Specific Absorption Rate (SAR) for Human Head between 2G and 4G Mobile Communication, 2018 International Conference on Engineering Technology and their Applications (IICETA).
12. Changqi Zhu, Dongsheng Wu, Lanlan Ping, Wenli Liang (2015) The effects of head parameters on the specific absorption rate in the human head, 2015 8th International Conference on Biomedical Engineering and Informatics (BMEI).
13. Ying Liu, Wei Cui, Yongtao Jia, Aidi Ren (2020) Hepta-Band Metal-Frame Antenna for LTE/WWAN Full-Screen Smartphone, IEEE Antennas and Wireless Propagation Letters 19(7).
14. Nibedita Mukherjee, Ardhendu Kundu, Bhaskar Gupta, Monojit Mitra (2020) Specific Absorption Rate Estimation for a Typical Hibiscus Flower Model as per ICNIRP Electromagnetic Guidelines, 2020 IEEE Calcutta Conference (CALCON).

ISSN: 2574-1241

DOI: 10.26717/BJSTR.2024.55.008688

Feng Xu. Biomed J Sci & Tech Res