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Size Reduction of UHF Planar Inverted-F Antenna with Patch Geometry Modification

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Abstract **– This paper deals with the design and experimentation of ultra high frequency (UHF) planar inverted-F antenna in reduced size with patch geometry modification. The antenna which intended to operate around frequency of 920MHz for medical implant application is deployed on a 0.8mm thick of FR4 Epoxy dielectric substrate. Prior hardware realization, the parameters of antenna including reflection coefficient, gain, and radiation pattern as well as its physical dimension are investigated numerically to obtain the optimum performance design. From experimentation, it shows that the realized antenna which takes a rectangular spiral shape for its patch and has the total dimension of 15mm x 15mm resonates at frequency of 915MHz with gain and bandwidth of -27.03dBi and 17MHz, respectively.**

Index Terms **— Geometry modification, planar inverted-F antenna, rectangular spiral shape, size reduction.**

I. Introduction

Recently, the researches related medical application especially implanted devices have attracted more attention in the microwave and electromagnetic researches community [1]-[3]. Due to its application for human body, there are a lot of requirements that should be accomplished by the device to be safely applied in the implementation. One of the requirements is that the device should be small enough so it will safe and not damages any part of body, while keeping its performances sufficient enough for the requirement of system. This also applies for antennas which are commonly used for transmitting and/or receiving data from the body to the measurement systems. To have small enough size of antenna with sufficient enough performance, a microstrip patch antenna has been one of solutions for the application due to its small dimension, light weight, low profile, ease for realization [4]-[5]. However, since the physical dimension of microstrip patch antenna cannot be made any shorter than half wavelength at the desired operating frequency, therefore several attempts have been carried out intensively to obtain the antenna in reduced size.

In this paper, a combination technique of planar inverted-F and patch geometry modification is proposed to reduce the size of microstrip patch antenna to be applicable for medical implant application. The antenna which is intended to operate at UHF band of 920MHz for medical implant application is designed to take a rectangular spiral shape for its patch and to be deployed on an FR4 Epoxy dielectric substrate. Some basic parameters such as reflection coefficient, gain and radiation pattern are employed as performance indicators both in the design and realization. Furthermore, the results of experimentation will be compared to the design results, and the performance evaluation of realized antenna will be presented for each parameter.

II. Overview of Planar Inverted-F Antenna Design

The final design of proposed rectangular spiral planar inverted-F antenna (PIFA) is illustrated in Fig. 1 in which the patch width (*A*) is 1.0mm, the separation between patch (*B*) is 0.7mm, the diameter of hole for shorting pin (*C*) is 0.6mm, and the distance from feed point to shorting pin (*D*) is 4.5mm. The antenna is deployed on a 0.8mm thick of FR4 Epoxy dielectric substrate with the total dimension of 15mm (*E*) by 15mm (*F*). The total length of microstrip patch made of metal copper which give the resonant frequency of 920MHz at UHF band is 90mm with the shorting pin located at 58mm along the microstrip patch from the feed point. To attain the geometry of final design above, some parametrical studies are carried out extensively to optimize the performance of proposed antenna.

Moreover, the thickness of microstrip patch on top side of FR4 Epoxy dielectric substrate as well as the groundplane on the bottom side is 0.035mm. To feed the antenna, an SMA connector is connected to the feed point form bottom side of dielectric substrate. While to achieve an accurate analysis, the copper conductive loss of patch and groundplane as well as the substrate dielectric loss are accounted for.

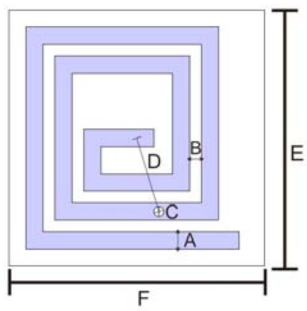


Fig. 1. Final design of rectangular spiral planar inverted-F antenna

III. Hardware Realization and Characterization

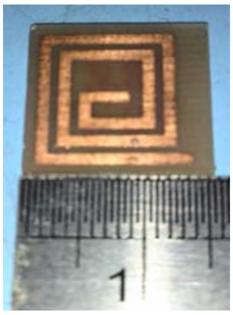


Fig. 2. Realized rectangular spiral planar inverted-F antenna

Fig. 2 shows the picture of realized rectangular spiral planar inverted-F antenna on an FR4 Epoxy dielectric substrate. The realized antenna which has been fabricated through wet etching technique is then characterized experimentally to measure its parameters to be compared with the design result. The experimentation results for reflection coefficient, gain and radiation pattern are plotted in Figs. 3, 4 and 5, respectively, with the design result depicted together as comparison.

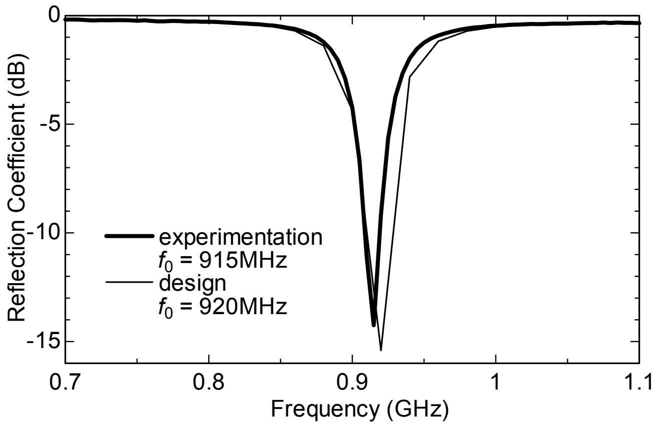


Fig. 3. Reflection coefficient of experimentation and design results

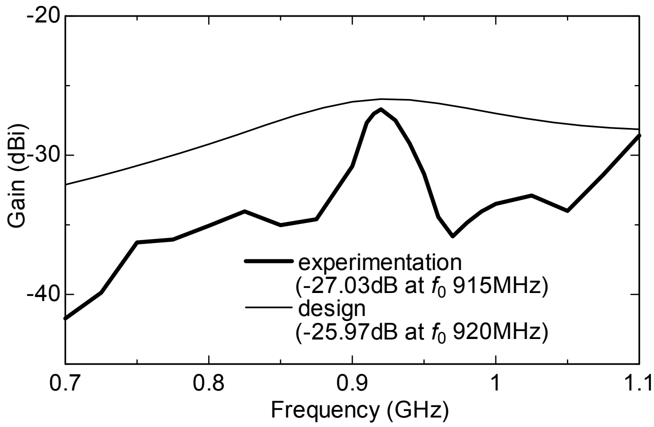
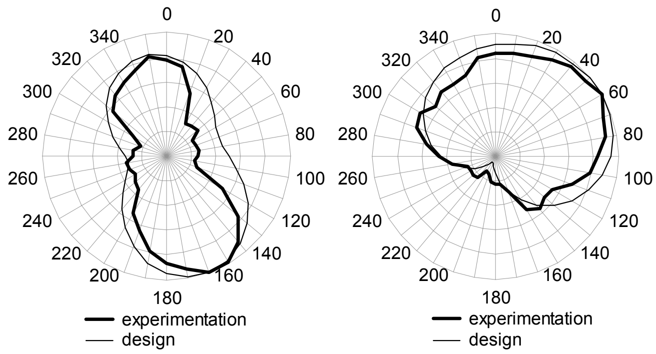


Fig. 4. Gain of experimentation and design results

From Fig. 3, it shows that the operating frequency of realized antennas is 5MHz lower than design result, i.e. 920MHz, with the bandwidth of 17MHz. The discrepancy is mostly evoked by the different value of relative permittivity of dielectric substrate which seems the relative permittivity in realization is higher than of the design. Moreover, due to the small size aperture of antenna, the gain of realized antenna as shown in Fig. 4 is very small around -27.03dBi at frequency of 915MHz, while the design result is -25.97dBi at frequency of 920MHz. The different gain is probably affected by the value of copper conductive loss and substrate dielectric loss set in the design and used in the realization. While the measured radiation patterns as depicted in Fig. 5 have good agreement qualitatively with the design result.



(a) *H*-plane (b) *E*-plane

Fig. 5. Radiation patterns of experimentation and design results

IV. Conclusion

A combination technique of planar inverted-F and patch geometry modification has been successfully implemented to reduce the size of microstrip patch antenna in producing a compact UHF antenna for medical implant application. The proposed antenna which has been deployed on a 0.8mm thick of FR4 Epoxy dielectric substrate has had the dimension of 15mm x 15mm. From design result, the proposed PIFA has had operating frequency of 920MHz with gain and bandwidth -25.97dBi and 21MHz, respectively. Whilst from experimentation, it has been demonstrated that the realized PIFA has resonated at frequency of 915MHz with measured gain of -27.03dBi and bandwidth of 17MHz. Although there was a different in some parameters, however it has been shown that the characteristics of realized antenna have good agreements qualitatively with the design one.

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