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Determining the Optimal Feeding Point for Simple PIFA using Current and Voltage Distribution

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Abstract: Planar Inverted-F Antenna (PIFA) is the most commonly used antennas for mobile phone applications because of their compact size and SAR properties. The bandwidth of an antenna is the set of frequencies over which the antenna reliably transmits or receives the electromagnetic waves. The reliable operation of an antenna requires low return loss which occurs due to reflections. The return losses are determined by the input impedance of the antenna. Hence it is important to choose the optimal feeding point having an impedance close to 50 ohm (characteristic impedance of feed) to reduce the reflections and hence the return loss. In this paper, a brief procedure is given on how to obtain the optimal feeding point for an antenna using the current and voltage distribution over the radiating surface. Also an approximate expression has been derived to obtain the optimal feeding point. It is possible to reduce the return loss to less than -20dB by this method.
Keywords: PIFA, Open EMS, feed point, Return loss, current voltage distribution.

I. INTRODUCTION

Antennas are required to operate efficiently over a range of frequencies by minimizing return losses. The reflections occurring at the load end can be minimized by setting the impedance of the load to that of the characteristic impedance of the feed. The characteristic impedance of feed is a 50 ohm resistance. Thus it is important to design the antenna and its feeding structure such that the antenna offers an impedance close to 50 ohm at the point of feeding.

In order to design the antenna , it is important to conduct a parametric study so as to understand the various design parameters and their effect on the performance. A parametric study was conducted in [1] studying the effects of width of shorting plate, width of feeding plate, feeding point, dimensions of PIFA. A parametric analysis was carried [2] studying the effects of the dimensions of the radiating part of antenna, thickness of antenna and effect of ground plane .The dimension of antenna, dielectric constant of the dielectric used will be generally used to control the resonant frequency, bandwidth can be controlled by using the width of feed and width of shorting plate, thickness of dielectric, ground plane . Various loading techniques like stub loading, inductive and capacitive loading techniques in addition to bandwidth enhancement techniques like parasitic element [3] are other tools at the disposal of the antenna design engineer. The loading techniques helped to reduce the dimension of PIFA. In order to have low return loss and high bandwidth matching networks are incorporated in the antenna structure. [4] provides a detailed study on matching techniques and also discusses in depth about PIFA. Finding optimal feed point for patch antenna using HFSS is done in [5]. Modelling of the patch is done and formulas are derived based on equations. Effective length of the feed is found in hfss to get one resonance frequency with better return loss. Voltage and current distribution are found [6] by changing the feed point in both the axis. Optimal feed point is found for coaxial, probe and port type of feeding methods.

II. CURRENT AND VOLTAGE DISTRIBUTION

In order to determine the feed point, it is important to know the current distribution, voltage distribution in the PIFA. Let us begin with the current, voltage distribution of a simple patch antenna which is the predecessor of PIFA. Figure 1 indicates the current, voltage distribution in a Simple patch antenna.

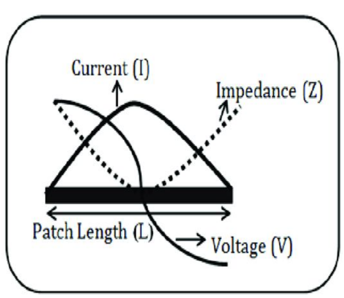

Figure 1: Current, Voltage distribution in a Simple patch antenna

The patch antenna is open on both the ends and hence has a zero current at the ends. The current increases as we move away from either ends . The voltage at the ends are maximum and decreases as we move away from either ends. Hence to satisfy the boundary conditions the patch has resonance when length becomes equal to λ/2.

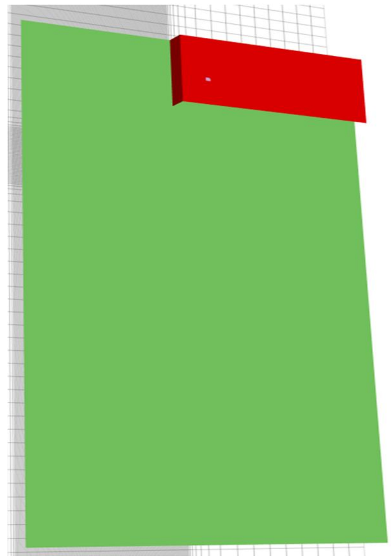

Figure 2: Simple PIFA

The PIFA is obtained by shorting the point of 0 voltage (maximum current) to ground and eliminating the part behind that point. Figure 2 indicates the structure of a simple PIFA. The white spot indicates the feeding point. Thus now the current and voltage are maximum at one end and 0 at another. The current being maximum and voltage being 0 at the shorting end and Voltage being maximum and current being 0 at the another. This also implies that the resonance now occurs when the length is equal to λ/4 (satisfying the boundary condition)

III. DETERMINATION OF THE OPTIMAL FEED POINT

We know that the current is maximum and voltage is 0 at the shorting end. Also by experimentation it is known that the maximum value of current is less than the maximum value of the voltage. Thus variation of voltage is faster than the current over the length of the antenna. The return loss is minimum when the impedance offered by the antenna is close to the characteristic impedance of the feed (in our case 50 ohm). Thus it is important to chose a point on the antenna which has the ratio V/I close to 50 ohm. By argument it is clear that feeding the antenna close to the shorting plate results in very low impedance. Also feeding the antenna close to open end results in very high impedance. Figure 3 and Figure 4 indicate the return loss and the impedance curves for feeding close to the shorting plate. The analysis in done for the antenna shown in Figure 2 having size 40 x 10mm, dielectric FR4 (εr = 4.4), thickness 4mm.

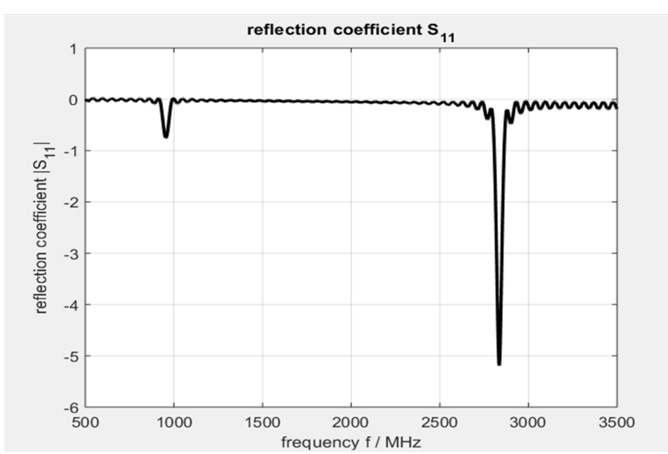

Figure 3: Feeding at 1mm from the shorting plate

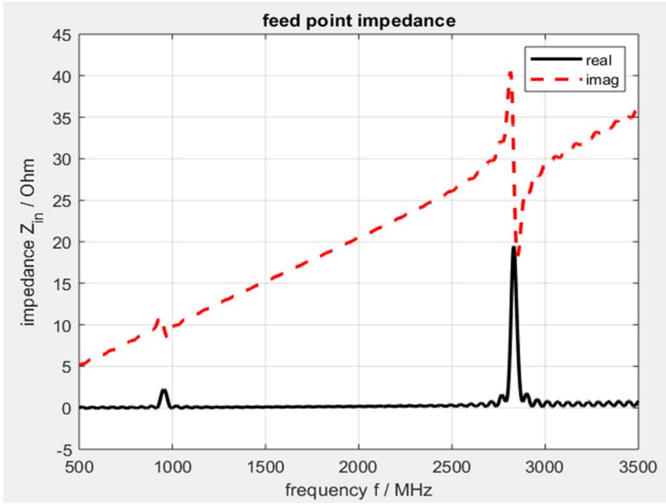

Figure 4: Impedance curve for feeding at 1mm from the shorting plate

Figure 5 and Figure 6 indicate the return loss and impedance curve for feeding at 1 mm from open end. (39mm from shorting end)

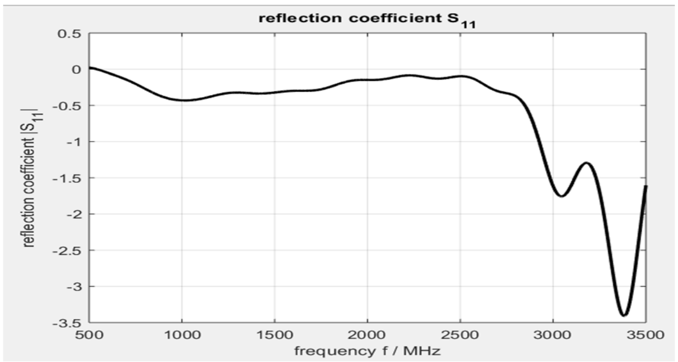

Figure 5: Return loss for feeding at 1mm from open end

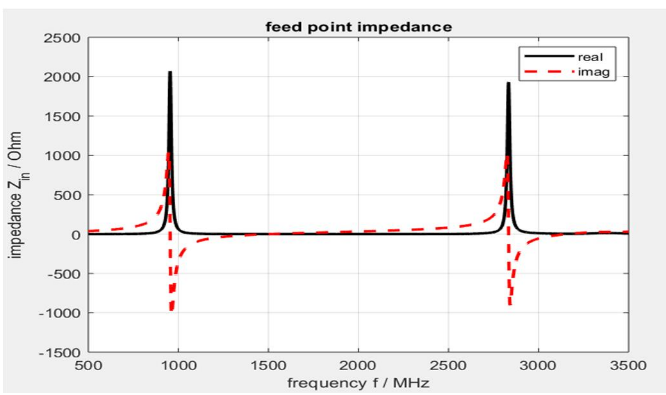

Figure 6: Impedance curve for feeding at 1mm from open end

Thus it can be seen that feeding close to open end results in resistance (real impedance is the only impedance during resonance) being high and feeding close to short end results in resistance being low.

In order to get V/I close to 50 ohm. We follow the below given procedure.

1) Choose a point generally at 1/3rd of the radiating length from the shorting plate. (so that voltage is sufficiently larger than current)
2) Measure the resistance at that point check if its greater than 50. If yes move towards shorting plate to attain 50 (as moving towards shorting end results in reduced voltage and increased current).If the resistance at the resonant frequency is lesser than 50 then move towards open end (moving towards open end results in increased voltage and decreased current).

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Figure 7 and Figure 8 indicate the return loss and impedance curve for feeding at 7.5mm from the shorting plate.

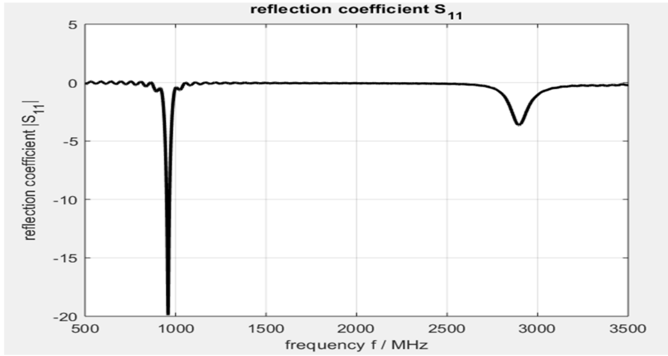

Figure 7: Return loss for feeding at 7.5mm from the shorting plate

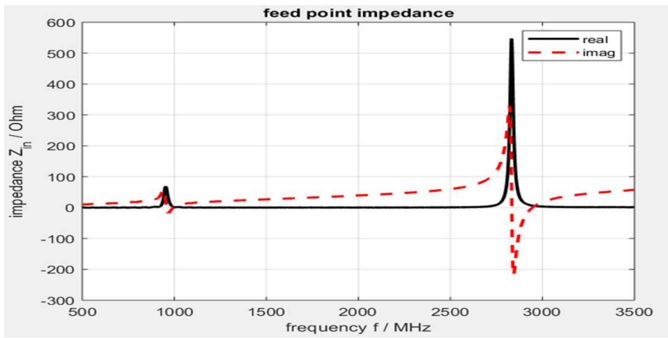

Figure 8: Impedance curve for feeding at 7.5mm from shorting plate.

It can be seen that the return loss has been optimized for the first band. If a resonance occurs at F then there are resonances at F, 3F, 5F,….(odd multiples of F). This is one of the properties of PIFA (wavelength corresponding to odd frequencies satisfy the boundary condition). Since the frequency 3F results in wavelength one third of the wavelength corresponding F. It implies that the same length of the antenna will now cover $3\lambda/4$. λ is the wavelength corresponding to 3F. Thus their current and voltage distribution have ¾ waveform contained in the same length. Hence it is difficult to optimize the return losses for both the bands.

In order to simplify the task, an approximate equation has been derived empirically. The voltage and current waveform can be represented by the equations

$$v = V\sin(2\pi x/\lambda) \quad (1)$$

$$i = I\cos(2\pi x/\lambda) \quad (2)$$

$$v/i = K\tan(2\pi x/\lambda) \quad (3)$$

Where x is the distance from the shorting plate. The constant K can be evaluated by finding the value of impedance at resonant frequency (mostly resistance) for some feed point x. Note that the above equations are approximate and hold good only in the case of simple PIFA for the quarter resonance wavelength.

IV. CONCLUSION AND FUTURE SCOPE

Simple PIFA is generally designed to resonate at quarter wavelength. Although this implies that there would be odd multiple resonances accompanying the frequency corresponding to the quarter wavelength say F. This is due to the unique structure of PIFA. It is important to minimize the return loss for the required frequency band. The method proposed above can minimize the return losses for quarter wavelength easily. But they do not hold good for odd multiples of F. Besides the method provides good intuitive understanding of how to select the feed point in general not just for Simple PIFA. However the equations given in this paper can only be applied to simple PIFA with entire width shorted.

By simulations we can in general reduce the return losses to as low as -40dB by this method.The modifications of the above method can be used to obtain feed points for simple patch, IFA and so on.

Minimizing return loss for multiple bands of Simple PIFA say F, 3F involves optimization techniques where the best possible solution may not be best for the bands if they are designed independently.

REFERENCES

[1] H.T. Chattha, Y. Huang, Y. Lu, Z.M.Huang "A Study of Parameter Changes on the Characteristics of Planar Inverted-F Antenna", 3rd European Conference on Antennas and Propagation, 2009

[2] H.-M. Chen, Y.-F. Lin, P.-S. Cheng, H.-H. Lin, C.T.P. Song and P.S. Hall, " Parametric study on the characteristics of planar inverted-F antenna" IEEE Proceedings - Microwaves, Antennas and Propagation (Volume: 152 , Issue: 6 , 9 Dec. 2005).

[3] Neha Loharia and Shashi B. Rana, "Review of PIFA" , IJECT Vol. 7, Issue 2, April – June 2016.

[4] Zhijun Zhang , " Antenna Design for Mobile Devices", Wiley IEEE Press, 2nd Edition 2017.

[5] Divakar, T. V. S. and Dhruba C. Panda. "Finding Optimal Feed Location of a Microstrip Patch Antenna using HFSS." International journal on innovative research in electrical, electronics, instrumentation and control engineering (2014): 2143-2145.

[6] S. E Jasim, M. A. Jusoh, M. H. Mazwir and S. N. S. Mahmud, "Finding The Best Feeding Point Location Of Patch Antenna Using Hfss ", Asian Research Publishing Network, ARPN Journal of Engineering and Applied Sciences.

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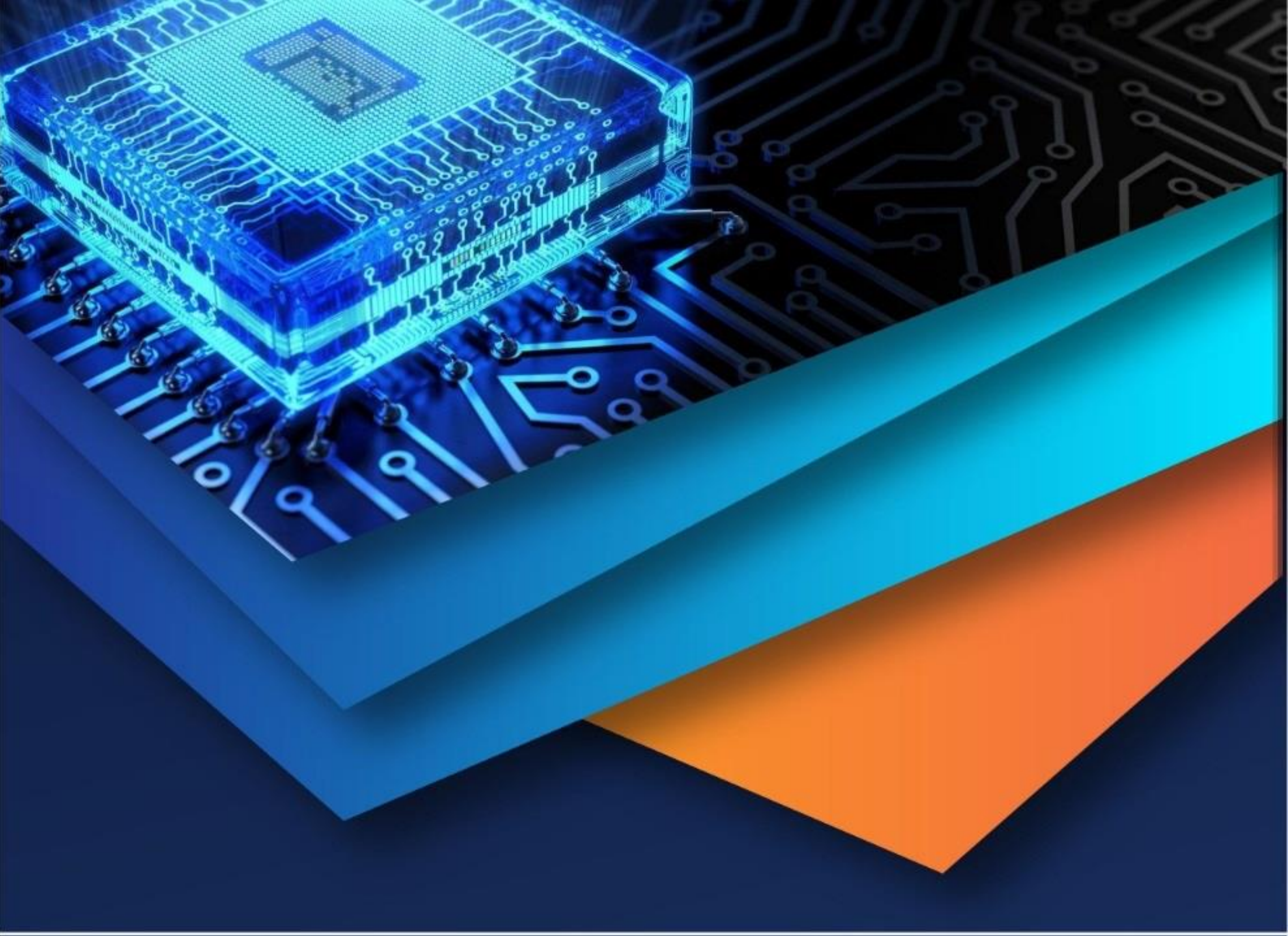

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