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Performance of Small Printed Antenna

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Abstract

In this paper, electrically small microstrip patches incorporating shorting posts are thoroughly investigated. These antennas are suitable for mobile communications handsets where limited antenna size is a premium. The performance properties considered in the design of small antennas typically include impedance, radiation efficiency, pattern shape, polarization and particularly operating bandwidth and quality factor (Q). Techniques to enhance the bandwidth of these antennas are presented and performance trends are established. From these trends, valuable insight to the optimum design, namely broad bandwidth, small size, and ease of manufacturing.

Introduction

Small antennas have been an important topic of research for many decades, and interest in the field is increasing with the development of new systems that require broadband antennas with a small form factor. The analysis of small antennas is generally considered to have begun with the establishment of the theoretical limits that show how electrical size and bandwidth are related. So Optimization of the performance properties of electrically small antennas has become very important and it has been given considerable attention in recent years

MICROSTRIP patches are currently being used for many applications due to several key advantages over conventional wire and metallic antennas. These advantages include low profile, light weight, and ease of fabrication and integration with RF devices. One such scenario is for use on a mobile communications handset. Here, although the above mentioned features of a printed antenna are compatible with this technology, the operational frequency is too low. However, there are several applications where even the physically small size of a conventional microstrip patch antenna is still too large. In the design of any small antenna, the performance-optimization goals include achieving an impedance match (low VSWR), high radiation efficiency, and a low quality factor (Q) or wide operating bandwidth. These are performance matrices that one like to optimize as there are trade -offs between them. Ideally we want to design the antenna in such a way that VSWR approaches 1:1, and the radiation efficiency approaches 100% over the desired bandwidth. Using high dielectric constant material has been proposed [1-3], however, so far, only poor efficiency due to surface wave excitation and narrow bandwidths have been achieved. Also, the limited availability of low cost, low loss, high dielectric constant material is another problem with this method. The fundamental approaches in modification of the antenna's structure include the use of capacity or top-hat loading, the use of multiple folded arms in wire monopole or dipole antennas , inductive loading in wire antennas (an increase in conductor length), and, more recently, the use of metamaterials and multi-arm coupled resonators. , the maximum reduction in physical size can be achieved if a single shorting post is used.

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Here, the radius of the circular patch was reduced by a factor of three, making the antenna size very suited for handset terminals. . In particular, the strong dependence of the input impedance on the close positioning of the shorting post with respect to the feed and once again the narrow impedance bandwidth. It should be noted that throughout this paper, the term shorted patch is used to describe a patch incorporating several shorting posts. It does not refer to the classical quarter-wave patch antenna where an edge of the radiator is terminated with a short circuit plane.

The impedance behaviour of the shorted patch radiator was qualitatively explained in using simple circuit theory and so, for the sake of brevity, will not be included here. However, it is important to note that at a fixed frequency, the modified patch size can be increased or decreased, depending on the distance of the shorting pin from the feed. Of course, this over-simplified approach ignores coupling between the fields from the edges of the patch and the pins[4-5].

Limitations of Quality factor and Bandwidth

The most significant challenge in designing a small antenna is optimizing the operating bandwidth, which is often characterized using the antenna's quality factor (Q). The frequency-dependent impedance of the small antenna is given by $Z(\omega) = R(\omega) + jX(\omega)$,where ω is the radian frequency, $R(\omega)$ is the antenna's total feed point resistance (including both radiation and loss terms), and $X(\omega)$ is the antenna's feed-point reactance. The bandwidth and Q of the small antenna are defined at radiation frequency $\omega 0$, where the antenna is either self-resonant, or made to be self-resonant, or tuned to resonance using a lossless series reactance. The small antenna's bandwidth is often characterized by its Q, because Q and matched VSWR bandwidth have been shown to be inversely related, and a lower bound on the minimum achievable Q is defined and well known. If the tuned small antenna exhibits a single resonance within its defined matched VSWR bandwidth.

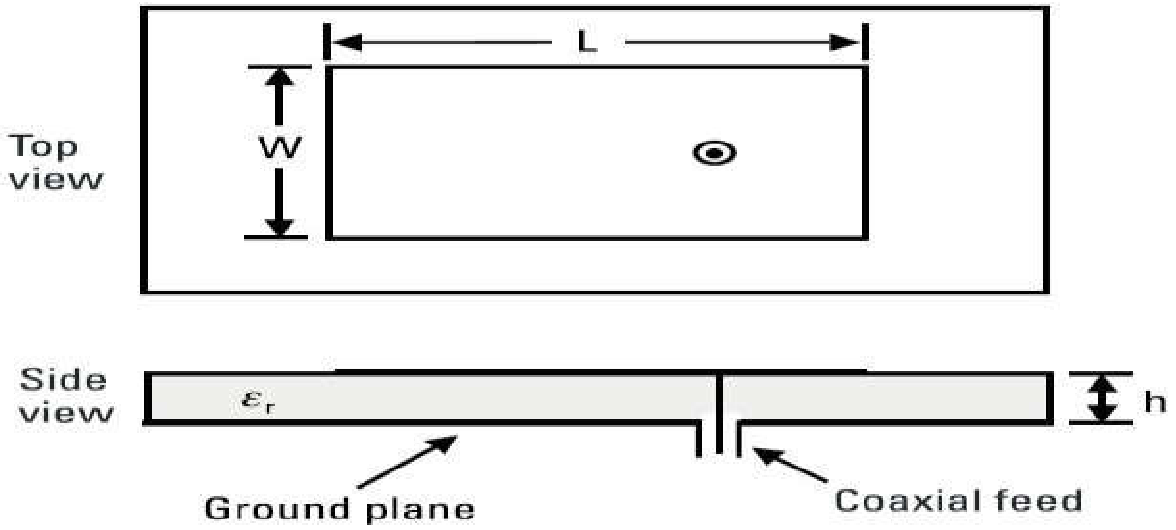
For the characterization of antennas bandwidth, we have to define bandwidth in such a way that the trade-off between VSWR and Q is visible, in other words they have to be inversely related. So we define the bandwidth as fractional matched VSWR bandwidth, FBWV as the ratio of the difference between two frequencies and resonance frequency[6-8].

presents a parameter study showing the effects of the height of the substrate, the dielectric constant of the material, the size of the feed and shorting pins; the effect of a cover layer on the electrical performance and manufacturing ease of the shorted patch is also provided. From this study, valuable insight into the optimum design of shorted patches is achieved; Section IV addresses the problem of the strong dependence of the impedance behaviour of the shorted patch on the close proximity of the feed to the pin. Here, a simple technique is proposed which overcomes this short fall.

Characteristics of shorted Patch

A shorted patch is a complicated radiating structure. Thus, to obtain an accurate representation of the electrical performance of this antenna, a full-wave analysis is required. Throughout this work, an analysis based on a full-wave spectral domain Green's function/Galerkin's technique was utilized. validation of the analysis will be given as well as a method to increase the impedance bandwidth of a shorted patch to that required for commercial mobile applications.

In this paper, a thorough examination of the probe-fed circular patch incorporating a single shorting post is presented. The design methodology will be summarized and comparisons with conventional probe-fed circular microstrip patches will be presented. The two comparisons to be made are with patches designed with the same substrate, and thus considerably larger, as well as circular patches of the same size as the shorted patch. To achieve the latter comparison, the dielectric constant of the substrate for the conventional patches was significantly increased to reduce the overall size. This latter comparison is probably the most appropriate for applications where size is of primary concern [9-10]. Finally, the performance trends of the shorted probe-fed microstrip circular patch will be presented, illustrating the effects of substrate parameters on the overall characteristics of these antennas.



Conclusion

In this paper, electrically small printed antennas were thoroughly investigated using a rigorous analysis. Several shorted patches with bandwidths suitable for commercial digital cordless systems were designed and developed. The influence of all the variables of a shorted patch on the electrical and mechanical performance of this radiator were investigated and from the study a design methodology and procedure were established. A novel technique which gives the structural problems of a shorted patch were also proposed. The shorted patch exhibits better efficiency and bandwidth characteristics but has higher cross-polarization levels than the conventional patch of the same size.

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