

Design and analysis of planar wideband monopole antenna using WIPL-D simulator

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Abstract. One of the problems that correspond to the small dimension of an antenna is the bandwidth. In order to overcome the problem from small linear and multiple antenna array systems, the investigation of the antenna elements is needed. The design of planar antennas is to achieve an antenna that is able to match various demands in applications where size, cost, performance, and aerodynamic profiles are very important considerations, a low-profile antenna such as a small. The antenna performance on scattering parameters S_{11} , gain, return loss and impedance input are investigated at obtaining wideband antennas by adjusting antenna design parameters. The substrate thickness needs to be adjusted to 0.813 mm, and the element length at 2 mm and 0.75 mm. The calculation of VSWR, gain, and the radiation pattern is presented using MoM-based WIPL-D. The antenna element when x_2 is 2mm in the frequency range 4 GHz – 8 GHz, which this antenna works best on element dimension $x_2 = 1.5$ mm when the frequency resonance 4.86 GHz and VSWR value is 1. The main advantages of this antenna are the dimension and simple design.

1. Introduction

For wideband applications, the design of planar monopole antennas printed by microstrip lines is the topic of this research. Single monopole is the basis for study before using it to form a linear array or two-dimensional antenna array system. The antenna element has a single T-shaped radiating patch fed by the microstrip line. This design was found to be useful for the entire C-band frequency. The loss of calculated profit is presented, which shows a bandwidth of more than 70%, with an input impedance of 50 Ohms. The radiation pattern is as presented for the antenna proposed at 6 GHz, showing very low cross-polarization. The effect varies the monopole dimensions of antenna performance have also been studied. Single element designs were analyzed using the MoM-based WIPL-D software package.

In applications where size, weight, cost, performance, ease of installation, and aerodynamic profiles are very important considerations, a low-profile antenna such as a microstrip patch is needed. Because microstrip antennas inherently have narrow bandwidth (BW) and, in general, are half-wavelength structures that operate at fundamental resonance [1], researchers have made efforts to overcome narrow BW problems, and various configurations have been presented to extend BW [2- 8], for example, by introducing slots in the microstrip patch configuration. Many studies have been carried out in the field of microstrip and array elements for the Synthetic Aperture Radar (SAR) application [9-12], especially to achieve an antenna that is able to match various demands. To meet the requirements for the 2.4 / 5.2 GHz application, several discoveries of flat printed antennas are presented in [13-15]. This study will



study the design of a wideband microstrip antenna with low cross-polarization for operation in the frequency range from 4 GHz to 8 GHz. Single element parameters are presented and discussed at the beginning of the study. This antenna element will be used to develop linear and multiple antenna array systems. The calculation of return loss is presented using MoM-based WIPL-D.

2. Literature review

2.1. Antenna

Webster's Dictionary defines an Antenna as a usually metallic device as a rod or wire for radiating or receiving radio waves. In other words, the antenna performs the function of transmitting and receiving electromagnetic waves [15]. An antenna is usually made from a metal pipe, conducting wire, or, as in this case, metal traces on a PCB. It is usually composed of a good conductor so that it can convert a received electromagnetic wave into electric current, which is then delivered to an electric circuit. For transmit, the antenna converts an electric current into an electromagnetic wave.

2.2. Single element antenna

The radiation characteristics of single-element antennas were discussed and analyzed. Usually, the radiation pattern of a single element is relatively wide, and each element provides low values of directivity (gain) [15]. In many applications, it is necessary to design antennas with very directive characteristics (very high gains) to meet the demands of long-distance communication. This can be accomplished by increasing the electrical size of the antenna.

The simplest and one of the most practical arrays is formed by placing the elements along a line. To simplify the presentation and give a better physical interpretation of the techniques.

2.3. Microstrip patch antenna

The MPA is a relatively new form of a radiator. In addition to compatibility with integrated circuit technology, it offers other advantages such as thin profile, lightweight, low cost and conformability to a shaped surface [15]. The main disadvantage is its inherent narrow bandwidth (typically a few percent) arising from the fact that the region under the patch is a resonant cavity with a high-quality factor.

The rectangular and circular patches are the basic and most commonly used microstrip antennas. These patches are used for the simplest and the most demanding applications. Rectangular geometries are separable in nature, and their analysis is also simple. The circular patch antenna has the advantage of its radiation pattern being symmetric.

2.4. Feeding technique

Three common structures are used to feed planar printed antennas. These are coaxial probe feeds, microstrip line feeds, and aperture coupled feeds. The coaxial –fed structure is often used because of ease of matching its characteristic impedance to that of the antenna, and as well as the parasitic radiation from the feed network tends to be insignificant [15]. Compared to probe feeds, microstrip line-fed structures are more suitable due to ease of fabrication and lower costs, but serious drawback of this feed structure is the strong parasitic radiation. The aperture coupled structure has all of the advantages of the former two structures, and isolates the radiation from the feed network, thereby leaving the main antenna radiation uncontaminated.

2.5. Impedance matching

The characteristic impedance of a transmission line, like coaxial cable, is the ratio of voltage to current for a wave traveling down the cable [15]. It is determined by the dimensions of the cable and the electrical properties of the material between the conductors. It is important because a traveling wave does not like the impedance to change. If the impedance changes, then a second, reflected, wave is launched. Reflected waves go back to the transmitter, and they do not get radiated.

To determine the loss of forwarded radiation due to returned power. VSWR results from mismatched impedance, to calculate the VSWR, first calculate the reflection coefficient:

$$VSWR = \frac{1+|\Gamma|}{1-|\Gamma|}$$

3. Method

In this study, using the MoM based simulator, WIPL-D to 3. Systematic analysis and evaluation of the performance of planar wideband monopole antenna are performed to realize the proposed structure and performance for wideband applications with a design frequency of 4 GHz to 8 GHz.

Designing the proposed wideband monopole antenna parameters such as substrate thickness, the monopole width and length, distance from the ground plane to the monopole antenna, the cut-off area on the back of the substrate, and the dimension of printed microstrip on the substrate. The structure of the proposed single and double T-shaped monopole antenna is shown in Figure 1.

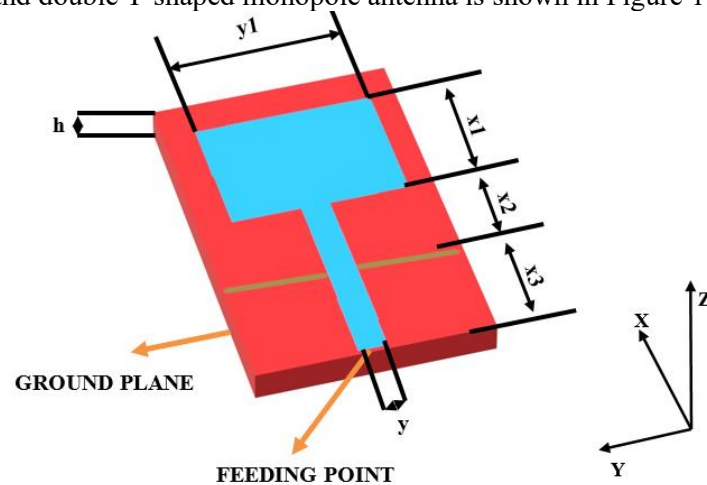


Figure 1. Single T-Shaped radiator antenna.

The basic topology for a single element of the proposed antenna is based on the developed monopole antenna introduced by Johnson and Rahmat-Samii [2]; however, our design shows a microstrip-fed line with different parameters for bandwidth intended for C-band operations. Printed microstrip-fed monopole antenna structure, shown in Figure. 1, printed on the substrate with thickness $h = 0.813$ mm and relative permittivity $\epsilon_r = 3.38$. The monopole width is represented as $y1$, and its length is $x1$. The $x2$ parameter is defined as the distance from the ground plane to the monopole antenna. The cut-off area on the back of the substrate, with a field area of 22×11.5 mm², is used for 50 Ohm impedance adjustments. The microstrip line is used to supply, with a length of $x3 = 11.5$ mm and a width of $y = 1.9$ mm.

4. Results and discussion

An empiric calculation has been performed on this antenna using WIPL-D EM Simulator. The effect of adjusting the value of $x2$ variation on the S11 parameter, gain, and VSWR. When $x2$ adjusted to 2mm, the gain is too far below -40 dB and the resonance frequency shift under 5 GHz. The following results of data retrieval can be seen in Figure 3.

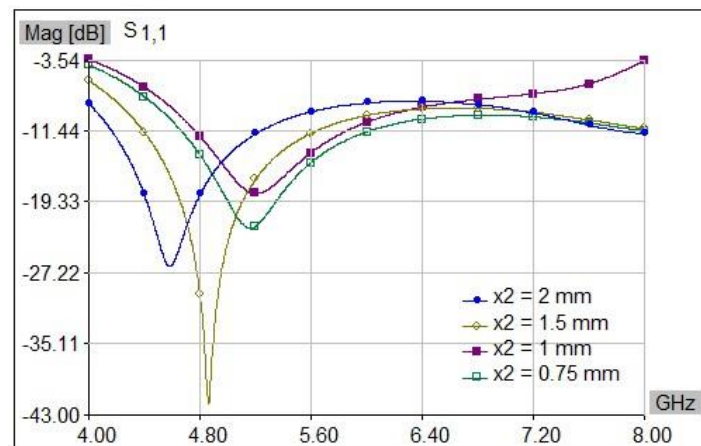


Figure 2. Gain affected by x_2 variation.

Figure 2 shows that the gain after the adjustment is too low. Then we adjust the x_2 to 1.5 mm, and the result is showing higher gain and resonance frequency. Gain and resonance frequency shifts affected significantly by how the current spreading across the element. A smaller element increases the current spreading. Gain becomes -40 dB, and resonance frequency shifts to 4.86 GHz with the wavelength under $1/4 \lambda$. The following result after adjustment can be seen in Figure 3.

Figure 3 shows the level of Gain of the antenna when the x_2 constant value is 1.5 on the smith chart. Resonance frequency shift to 4.86 GHz shown in smith chart tick the value of 1 in the smith chart and VSWR value reaches one on 4.86 GHz.

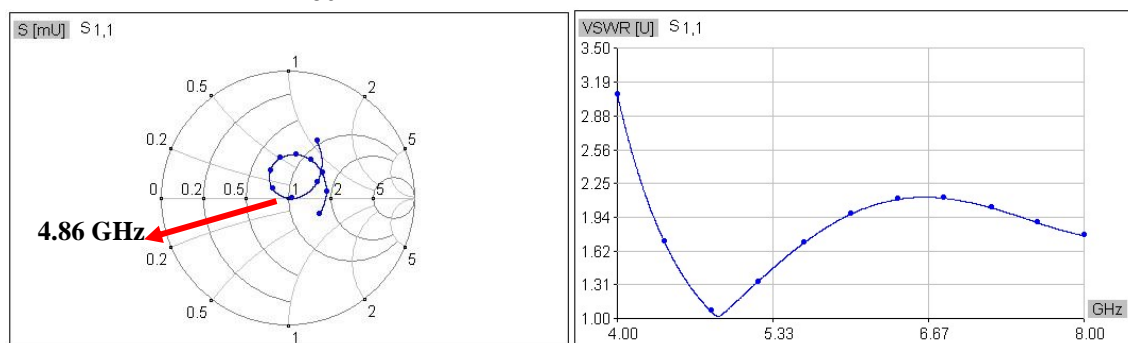


Figure 3. Smith chart and VSWR on $x_2=1.5$ mm.

5. Conclusion

Based on data retrieval that has been investigated and calculated by WIPL-D can be concluded that this antenna works best on element dimension $x_2=1.5$ mm when the frequency resonance 4.86 GHz and VSWR value is 1. The main advantages of this antenna are the dimension and simple design.

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