Design and Realization of Broadband Loaded Antenna with Matching Networks

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Abstract

The successful design and physical realization of broadband loaded wire monopoles with matching networks was presented in this paper. Loading circuit parameters, locations of the loads along the antenna, as well as matching network parameters were analyzed with the aid of an optimization routine and the method of moments (MoM).Thereafter an omnidirectional broadband miniature antenna used for a portable radio station was designed and manufactured, which worked in the frequency range of 30~512MHz. The VSWR of the antenna was less than 3.5 and the radiation gain was larger than -15dBi over the whole frequency band

Keywords

broadband miniature antenna, matching network, method of moments (MoM).

1. Introduction

In modern communication systems, with the development of spread-spectrum and frequency-hopped techniques, broadband omnidirectional miniature antennas for modern communication become more and more important and need to be researched as soon as possible[1-3]. Loading and adding a broadband matching network to the antenna seem to be an interesting solution to decrease the size of wire antenna and expand its frequency band[4,5].

This paper gave emphasis on computation and design of the loaded antennas. A loaded antenna could be obtained by placing electrical impedances on wire radiators, in order to properly modify the current distribution along the wire antenna, consequently, enhance the input impedance, the radiation pattern, and the efficiency of the antenna. A Fortran program was written to determine the electric current distribution on the antenna by the method of moments, with the purpose of enhancing the desired antenna performance. Finally, through loading with lumped components and adding a matching network, an omnidirectional miniature antenna having bandwidth ratios of 17:1,with measured VSWR less than 3.5 and calculated system gain greater than -15dBi over the whole frequency band(30-512 MHz), was designed and physical realized.

2. Antenna Design

It is generally known that the parallel and series LC circuits respectively act as an open and a short circuit at their resonant frequency and as reactive loads elsewhere, so a loaded antenna could be obtained by placing lumped impedances[6,7]. Besides the antenna loading, a lossless matching network was also introduced in order to further reduce the VSWR.

The geometry and configuration of the proposed portable radio station antenna was illustrated in Fig.1.The length of radio station is 0.24mm, the width is 0.1mm, the height is 0.3mm.By incipiently optimization with the aid of a genetic algorithm(GA) , electrical components are loaded at the point which is 0.406m from the bottom of the antenna. The loaded resistance $Z_C = 571.0\,\Omega$, the loaded inductance $L_C = 1.87\mu H$ .The broadband matching network was illustrated in Fig.2. The values of the components were listed in Table 1.The computing VSWR with these parameters were shown in Fig.3.

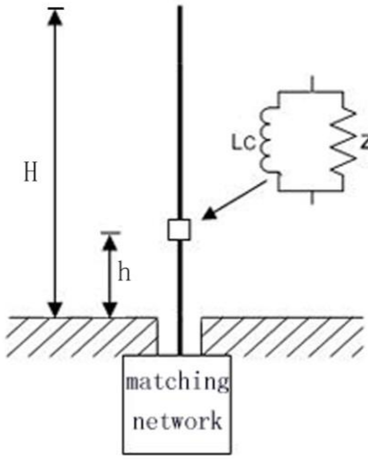

Fig.1 The geometry of the proposed antenna.

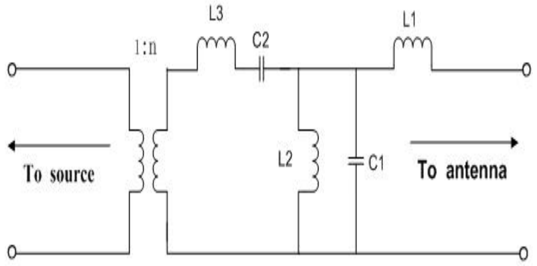

Fig.2 The broadband matching network topology

Table 1. The values of the matching network components

Parameters	L1	L2	L3	C1	C2
Values	72.9nH	570.4nH	69.4nH	2.87pF	27.9pF

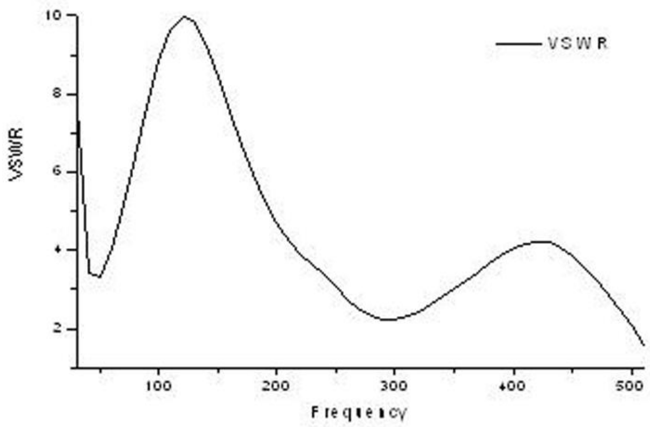

Fig.3 The VSWR of the antenna

3. Parameters Analysis

The influences of components of loading and matching network were analyzed respectively below.

1).Effect of the loaded resistance Zc (Fig.4): It was found that varying the loaded resistance could affect the lower-band of the antenna, especially in the range of 100-200MHz .

2). Effect of the loaded inductance Lc (Fig.5): The loaded inductance played an important role in determining the VSWR of the antenna in 50-200MHz.The VSWR were descending rapidly with the decreasing of loaded inductance.

3). Effect of the shunt-wound inductance L2 and series-wound capacitance C2 (Fig.6 and Fig.7):They could improve the VSWR in the range of 30-200MHz, without affecting higher-band of the antenna.

4). Effect of the series-wound inductance L1 and L3 (Fig.8 and Fig.9): They could improve the VSWR in higher-band without affecting lower-band of antenna.

5). Effect of the shunt-wound capacitance C1 (Fig.10):It affected the VSWR in the whole band especially for the higher-band of antenna. The VSWR increased rapidly with the decreasing of loaded inductance.

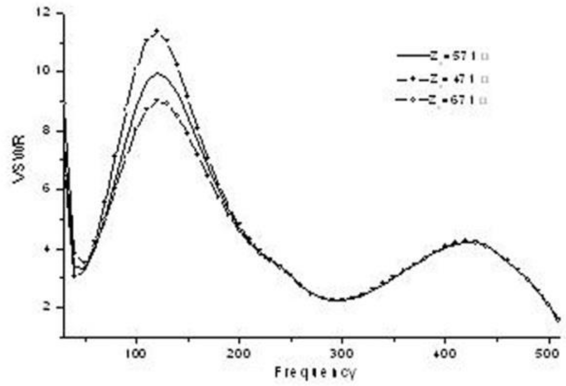

Fig.4 Effect of the loaded resistance Zc

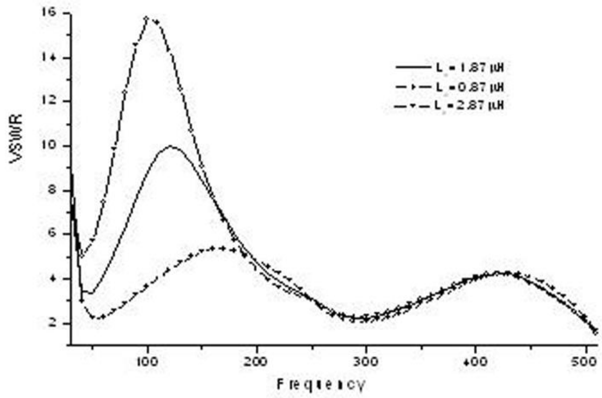

Fig.5 Effect of the loaded inductance Lc

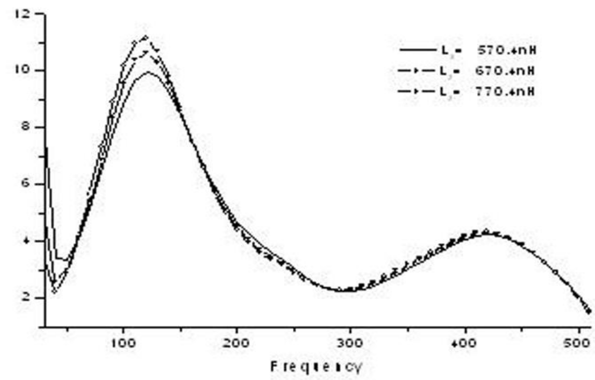

Fig.6 Effect of the shunt-wound inductance L2

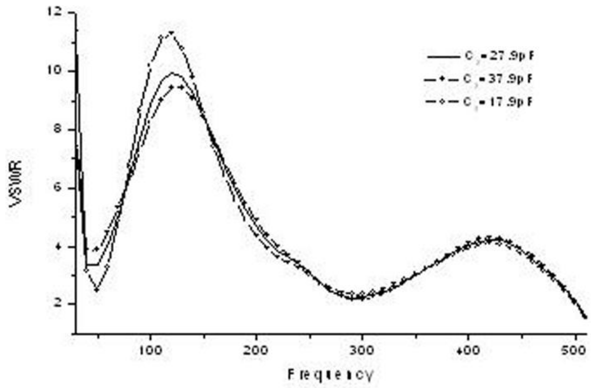

Fig.7 Effect of the series-wound capacitance C2

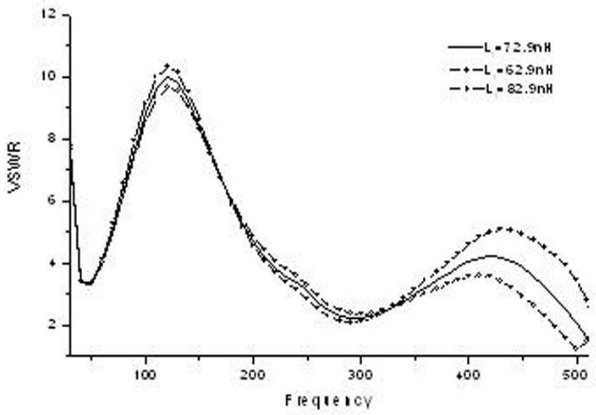

Fig.8 Effect of the series-wound inductance L1

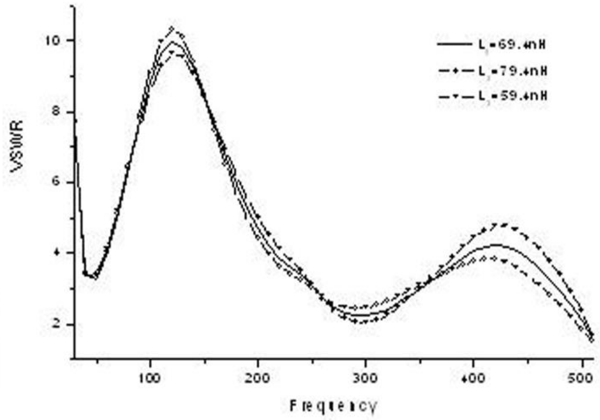

Fig.9 Effect of the series-wound inductance L3

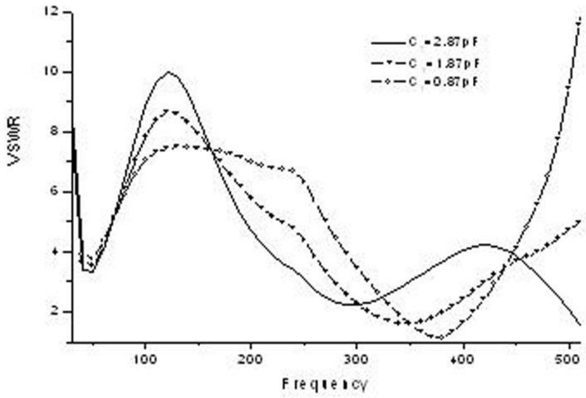

Fig.10 Effect of the shunt-wound capacitance C1

4. Experimental Results

Through adjusting the loading circuit and matching network parameters, the final optimized results are gained with the parameters $Z_C = 551.0\Omega$, $L_C = 430nH$, $L_1 = 909nH$, $L_2 = 850.4nH$, $L_3 = 49.4nH$, $C_1 = 2.87pF$, $C_2 = 27.9pF$ .The VSWR characteristics of this antenna were depicted in Fig.11. It was demonstrated that the gains of antenna were larger than -15dBi over the whole frequency band, as shown in Fig.12.The proposed antenna was manufactured and the VSWR was measured using the WILTRON37269A vector analyzer. Figure 13 showed the measured VSWR against frequency for the designed antenna. It was observed from the measured results that the VSWR of the antenna was less than 3.5 over the whole frequency band.

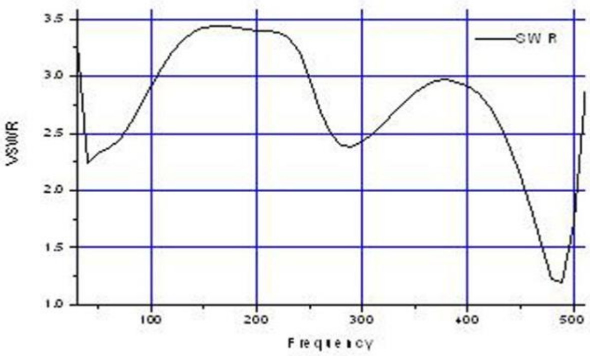

Fig.11 Final simulated VSWR of the antenna

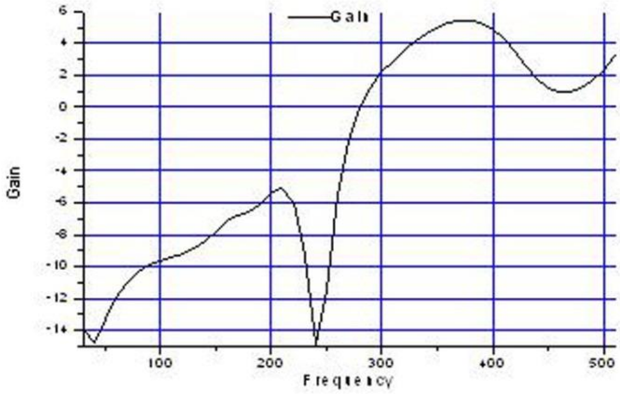

Fig.12 Final simulated radiation gain of the antenna

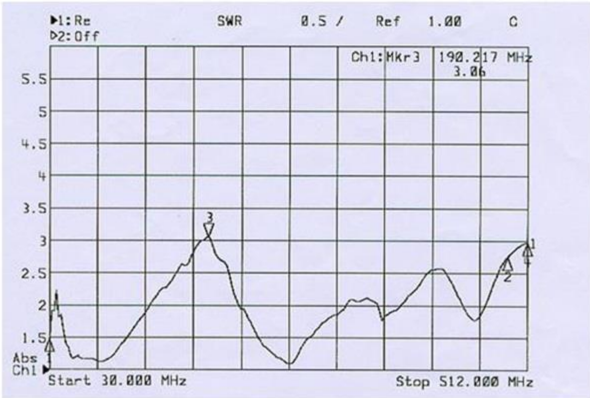

Fig.13 Measured VSWR of the proposed antenna

5. Conclusion

An omni-directional broadband miniature loaded antenna with matching networks was presented in this paper. The effects of the various parameters on the antenna performance were studied. Simulated and measured results indicated that the proposed antenna satisfied the demands.

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